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What Do I Get for My Three Dollar Membership?

Presidential Address, Sixty-Third Annual Meeting, American Association of Economic Entomologists

ROY E. CAMPBELL, *Bureau of Entomology and Plant Quarantine*

The constitution of our Association states that it shall be the duty of the President to preside, and to prepare an address to be delivered at the annual meeting, over which he presides. This would indicate that presiding and making an address are the President's most important duties. This may have been true at one time, but at the present time he has many more important duties.

However, such stress on a presidential address has caused me (and no doubt my predecessors) a great deal of worry. Shortly after being nominated for President, I woke up suddenly one night with the paralyzing thought, "If I *should* be elected, I'll have to give a presidential address!" I lay there in such mental agony that it seemed hours before I could get to sleep again. But at last I drifted off into a hazy dream. I actually was giving my presidential address, but it was so impossibly bad that it became the last one ever delivered before the Association! That part of the dream about its being the *last* address was prevented from coming true by only a very few votes.

The first thing a person thinks of when considering the necessity of preparing an address is "What would be a good subject?" After asking themselves that question, it is my guess that most presidents of this Association then thought, "Well, let's see what our predecessors had to say." So, following this precedent, I got out the back JOURNALS and read over the addresses of some of the previous presidents. They covered a wide range of subjects, mostly along the lines of the special interests of the individuals. I was impressed with the excellence of the addresses as a whole, and also with the clear and precise manner in which each author developed the theme of his particular address. I was also impressed with the length of some of them. The one I liked best was Dr. Cory's. It was only three and one-half pages long. That gave me one bright idea, but it failed to suggest a subject for *my* address.

During the course of my first Presidential visit to a Branch meeting, one of the members said to me, "When I suggested to a prospective member that he join the Association, he asked me what he would *get* for his $3.00." Since I had already decided that during my year I would stress the matter of getting new members, the thought instantly flashed through my mind, "That is the subject of *my* presidential address—WHAT DO *I GET* FOR MY $3.00 MEMBERSHIP."

It is a good question. While thinking about this subject, I read an address by Henry J. Kaiser on "How to Capture Life's Greatest Values." In this he states, "An attitude of—What will I get *out* of it?—leads up a blind alley of failure." This question does seem to be somewhat materialistic at first thought, but let's consider it further.

First, a member must pay $3.00 a year for his dues. Second, he can then subscribe for the JOURNAL for $3.50, whereas a non-member must pay $8.00. That is a saving of $4.50. Third, a member has the privilege of purchasing the *Index of Economic Entomology* at cost ($3.50 for the latest issue), while non-members must pay $7.00. Fourth, members get a free copy of *Entoma*, costing $1.50 to non-members. Fifth, when and if the new *Bulletin* is issued, it will be free to members. Sixth, a member also has the privilege of publishing his papers in the JOURNAL OF ECONOMIC ENTOMOLOGY, providing, of course, that the paper meets the usual editorial

requirements. Non-members cannot get a paper published unless it is of very exceptional quality, and then they may have to pay the cost of publication, which is now $10 per page. To a young entomologist trying to get a start and to establish a reputation for his work, this publication privilege is invaluable, and worth many, many times the cost of membership. There is another privilege applicable only to members, not so materialistic, but one of considerable value, and that is the privilege not only of voting, but also serving on committees, and holding office in the Association and its Branches.

This may not be a very impressive list, but the monetary total of savings for a member would be at least $7.00 annually, not including *publication* privileges. Since the average paper is 5 pages in length, that would be worth $50.00.

We have heard a great deal about what a good investment Government bonds are. Invest $3.00 and you get back $4.00. But you have to wait 10 years. Now if you join the Association for $3.00, you get at least $7.00 in additional benefits, and you *don't* have to wait 10 years to get it! You get it every year.

That pretty well covers the purely *materialistic* picture, but there is another viewpoint which is worthy of discussion, one which is of much more importance and significance, and that is—the *altruistic* viewpoint. The important thing is not—What can I *get* from the Association for my $3.00—but—What can I *contribute* to the Association by joining?

Before we consider this, let's examine the Association and the present status of entomologists. The Association was founded in 1889, with 22 members. Growth for a long time was slow. It was not until 1920, 31 years later, that our membership reached 600. After that, there was a rapid increase, reaching 1500 members by 1940, and nearly 2500 by 1950. The latest report from the secretary shows 2950 members, and we expect shortly to exceed 3500. You will readily see that this gives us considerable numerical strength.

But numerical strength alone is not enough. During this period, what has happened to entomology as a science? At first, most of those interested in entomology were amateur collectors of insects. There were a few museum workers, a few research workers and a few teachers who gave elementary courses. Under these conditions entomology was not ranked very high as a science. A number of years ago I remember hearing one of our members who was head of a Department of Zoology and Entomology at a prominent university say, "As a professor of zoology, I can stand up on a pedestal and look way down on myself as a professor of entomology." Formerly many of our entomologists had little formal education in entomology, and some of them holding high positions and doing excellent work, were not even college graduates. No one questions the great contribution of these men to entomology, but one has to admit the low scientific standing of entomology and entomologists under such circumstances.

But that picture has changed. Whereas formerly only a few colleges and universities gave courses in entomology, which were rather general in most cases, now a great many educational institutions, both public and private, give complete courses in entomology leading to Bachelor's, Master's, and Doctor's degrees. These courses include all phases of entomology—systematic, economic, insect toxicology, insecticides, biological control, etc. This work in entomology is based on fundamentals of zoology, botany, mathematics, chemistry, etc. To even be eligible for a position as entomologist with the Federal or State governments, and in most univerisities and colleges, one must be a college graduate, and in many cases a Doctor's degree is necessary. So at the present time, in academic training, in advanced degrees, in quality of research and teaching, and in position requirements, the entomologist can now take his place along with *any* of the other scientists.

In his profession, the entomologist has carried out such excellent work in controlling insects which affect our crops, our stored foods, our wood and fiber products, and especially the insects which affect the health of man and animals, that he is beginning to get the recognition which is due him.

During the war the entomologist gave outstanding service to the country in controlling the various insects which might have transmitted diseases to our military men which would have made them unfit for combat. If we wanted to brag, we might

say that the war was *won* by the entomologists; at least, it couldn't have been won without them.

Entomology has also come to the front as a business. The manufacture and sale of insecticides and of machinery for insecticide application, together with the commercial application of these insecticides in the control of all kinds of insects, has really become *big business*. Even though this part of entomology is primarily commercial, much of it is in the hands of trained entomologists who have had a great deal to do with establishing entomology on the reputable business basis which it has today.

When I first began entomological work (*many* years ago), there were only a few large insecticide companies, and a very few commercial research entomologists. Insecticide field men and company representatives were also scarce. But there were many small companies selling "cure-alls" and highly touted materials with secret formulas, most of which were more or less innocuous to insects. Registration and labeling requirements were very lax or entirely lacking. Entomologists paid by Federal or State governments held themselves aloof from commercial men, and were reluctant to test any of their materials. In most cases we refused to make any tests whatever with the materials, or declined to make tests without knowing what the ingredients were, and they refused to give us information of this kind.

But this situation has gradually changed. The secret formulas and the cure-alls were abandoned. Labeling of contents became a requirement by law. Commercial companies hired trained entomologists to test their insecticides, and also began furnishing materials for tests to be made by public-paid entomologists, together with full information about the ingredients. These public entomologists made exhaustive tests of these materials without any obligation to the companies, and reported their results to the companies and to the public, whether such results were good or bad.

Commercial men and public entomologists now feel free to exchange information and ideas, and a feeling of mutual respect and trust has been built up. It is my opinion that these friendly relations between the two groups are mutually very beneficial. It has had much to do with building up a highly efficient, repected, and reliable industry. It has also been effective in the removal of the "holier-than-thou" attitude which was too prevalent among many public-employed entomologists in former years. As these associations continued, each group gained information about and respect for the needs and problems of the other group. So at the present time we find an alert and dynamic industry, and an active group of public and private entomologists working together for one objective—namely, *better* control of our insect pests.

Now that we have examined the progress of the Association and found out that it is making a rapid growth; and also that the present status and scientific standing of entomologists have greatly improved; and that in addition we have a large and prosperous business connected with entomology, we can go back to the question: "What can *I contribute* to the Association by joining?" And,—"What benefits to the Association, to other entomologists, and to my profession will come as a *result* of my joining?"

By joining, you have given your moral and financial support to the organization whose avowed purpose is—"to promote the study, and advance the science of entomology." As the Association increases in size, it becomes more able to carry on its several purposes, to interest itself in the many and varied entomological problems which face the nation, and to exert influence along these lines for their solution in the most satisfactory manner.

In addition, there is the feeling you have that as your profession advances, becomes more effective, and renders greater and greater service to the nation, *you* have had a small part in it, not only in your own work, but by joining with others in the work of advancing the science of entomology, as a large and active Association *can* do. If we, working together through our Association can improve the status of entomology and entomologists. we will improve our own *personal* status, That is enlightened self interest.

Every profession and business has its own organization to advance its interests, such as the American Bar Association, the American Chemical Society, the American Medical Association, the National Agricultural Chemicals Associa-

tion, the National Canners Association, and dozens of others. Last year while passing through Chicago I had dinner at one of the leading hotels there. The crowds in the lobby indicated a convention was in progress. I asked a bellboy what convention it was, and he said it was some group of doctors. Then I saw a large sign reading "N.A.U.M.D." But the *M.D.* in the sign did not mean that they were doctors. It was the National Association of Used *M*aterial *D*ealers. So, it seems that even the junk dealers have a national organization, and they are active in promoting their interests and welfare. If it is worth while for other business men and professional men in such diverse categories as doctors and junk dealers to join and support their respective national organizations, then surely the entomologist will find it well worth while to "go and do likewise."

The late Dr. Rohwer in his presidential address at New York on the subject "Entomology and Entomologists" brought out that the entomologists' contribution to the last world war and to the health and comfort of the people throughout the world is recognized in a general way, but nevertheless it is still a fact that the full extent of the great service of entomologists in protecting food and fiber from insect damage is not properly recognized. Dr. Rohwer believed this to be largely due to the entomologists themselves. They have *not* made *sufficient* effort to let people know how much they are doing. Building a strong Association is one way in which greater recognition for entomologists can be achieved.

During the year just passed, some additional recognition came to the Association. We were asked to appoint a representative on the Joint Committee on Grassland Farming. This committee was organized by Agricultural Experiment Station research workers and farm machinery representatives to stimulate and encourage research work on the production, harvesting, and utilization of grass and legume crops, and to collect and disseminate useful information on problems related to grassland farming. Since one of the problems met in grassland farming is damage by insect pests, it is of course appropriate for the Association of Economic Entomologists to have a representative on that committee, along with the representatives of other similar cooperating organizations.

We were also asked to name a liaison representative on the Food Protection Committee of the National Research Council. Since we realize the vital need for the use of insecticides to protect food crops and food products from destruction or damage by insects, and we also realize that pesticides may be poisonous to humans, and their use on food stuffs must be properly handled, it is very fitting that through the Association, we as entomologists have a representative on this committee.

There are many people with good intentions but inaccurate information, who would try to prevent the use of insecticides altogether, and in fact all chemicals on food crops and food products. We must be constantly on the alert, as individuals and through the Association, to inform the public that we are concerned not only with protecting the interests of entomologists and food producers, but we are also concerned with protecting the consumers of food products against the erroneous or careless use of insecticides, so that through their proper use more and better food can be produced.

Our Association should be so strong, so active, and so interested in all entomological problems that we are consulted and represented whenever some question along these lines comes up, or when any action is contemplated involving insect control or the use of insecticides. In this way we can see to it that our greatest interest, the proper control of insect pests so as to protect food stuffs, fibers, human and animal health, is not jeopardized.

The answer to the question "What do *I get* for my $3.00?" is that you will get more than your money's worth in material things. In the personal satisfaction of helping to advance entomology and entomologists by making a better and more effective Association, what you will get out of it will be in exact proportion to what you put into it. Our Association will grow, prosper, and spread its influence and be effective in advancing the interests of entomology and entomologists entirely according to the efforts made by its members.

Nemestrinid Parasites of Grasshoppers

GEORGE T. YORK and HUBERT W. PRESCOTT, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*[1]

Two species of dipterous parasites of the family Nemestrinidae have been found in certain species of grasshoppers in Montana. These have been identified as *Trichopsidea* (*Parasymmictus*) *clausa* (O. S.) and *Neorhynchocephalus ackeni* (Will).[2] In most places where they were seen, the adult flies of the two species were about equal in numbers. In one location, where the grasshopper *Metator pardalinus* (Sauss.) comprised 95 per cent of the population, only *T. clausa* was found.

REVIEW OF LITERATURE.—Revisions of the Nemestrinidae have resulted in changes in spelling of scientific names but these changes have been of such a nature that the species can still be identified, hence the spelling as used in the original articles has been followed in this review. Bequaert (1934, 1947) gives a complete account of the Nemestrinidae of North America, including reports of collections from a number of the central and western states. As early as 1894 Williston (1894) reported that Professor Brunner had observed *Rhynchocephalus sackeni* ovipositing in *Eriogonum alatum*. However, Williston doubted whether the species could pierce the woody tissue of the plant for oviposition and thought it more likely that the females deposit eggs in holes of woodboring insects, a habit that had been noted in *Hirmoneura obscura* Meig., another species of Nemestrinidae. Spencer (1931, 1932) in British Columbia reported the oviposition of *R. sackeni* in beetle holes in telephone poles and assumed that the larvae were parasitic on the beetles. In a later publication (Spencer 1945) he recorded rearing *R. sackeni* and *Parasymmictus clausus* from grasshoppers. Smith (1944) reported *P. clausus* from two areas in Manitoba. Bequaert (1950) reported that a female *Trichopsidea clausa* had been reared from *Metator pardalinus* in 1942 by R. E. Pfadt, and stated further: "This is the first specimen bred in the United States that has come to my notice, although there may be unpublished cases in certain files."

Various species of Nemestrinidae are found throughout the world. De Crouzel & Salavin (1943) reported on two species found in South America. Shulov (1948) found an unidentified nemestrinid larva in *Schistocerca gregaria* (Forskal) which, according to B. P. Uvarov, was the first record of a nemestrinid parasite in this species of grasshopper. Potgieter (1929) reported on Nemestrinidae in South Africa. Noble (1936) gave a brief account of *Trichopsidea oestracea* (Westw.) in Australia, which was followed by a more complete report by Fuller (1938) giving descriptions and photographs of larvae and pupae.

In the study of the grasshopper problem on range land in Montana during 1949 and 1950, the writers made a number of observations on the Nemestrinidae in the area. Since the available information on these parasites is rather limited, and the parasites were so abundant in certain localities, it seemed worth while to publish the results.

GENERAL APPEARANCE.—The adults are flies similar in color to honey bees but slightly smaller. In habit and coloration they so closely resemble bees that they are definitely avoided by the layman. Some stockmen have killed the flies thinking they were botflies. Members of the family Nemestrinidae may be distinguished by the unusual amount of anastomosing of the wing veins and the resultant prominent vein extending across the wing and ending posteriorly about one-third of the distance from the wing tip. *Neorhynchocephalus sackeni* is, in general, somewhat smaller than *Trichopsidea clausa* and may be distinguished from the latter by its prominent proboscis.

The most distinguishing characteristic of a larva while in the host is the rather elongate respiratory tube with its cuplike process which fits over the posterior portion of the larva and extends to its attachment with the host. When the larvae reach maturity and are leaving the host

[1] Acknowledgment is made to J. R. Parker, in charge of the Bureau's grasshopper research investigations, Bozeman, Mont., for his interest and encouragement in the work. L. E. Fourtner, Forsyth, Mont., photographed the adult flies, and C. O. Esselbaugh, of the Bozeman laboratory, made the photograph of a larva emerging from a grasshopper.

[2] Determinations by W. W. Wirth, Division of Insect Identification, Bureau of Entomology and Plant Quarantine.

FIG. 1.—Females of *Trichopsidea* (*Parasymmictus*) *clausa* (O.S.) ovipositing on fence post.

this respiratory tube is shed and remains in the body cavity of the host.

LIFE HISTORY AND HABITS .—The life history and habits of the two species studied were very similar. The only difference noted to date was in the species of grasshoppers infested, as will be discussed later.

In 1950 the first adults of *Trichopsidea clausa* were noted on June 13 near Colstrip, Mont., but only a few males were seen. The next observations were made on June 20, when large numbers of females were present busily engaged in egg laying. By July 6 all adults had disappeared from the area. However, in other areas adults

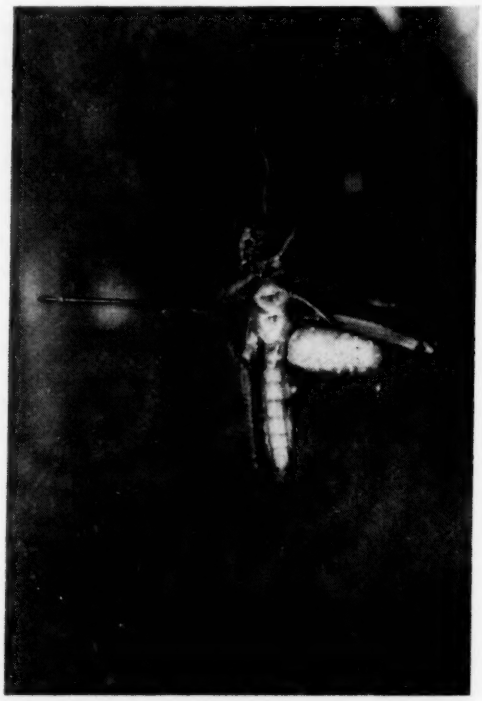

FIG. 2.—Nemestrinid larva emerging from grasshopper.

were seen as late as the end of August. Since the time of emergence will vary from year to year, depending on meteorological conditions, the appearance of adult flies can best be associated with grasshopper development. In 1950 the emergence of flies started when the early developing grasshoppers had reached the first and second instars.

The adults are apparently short lived. When confined in cages the flies lived only a day or two and under natural conditions they probably do not survive more than a week.

Adults were never observed feeding although a number of wild flowers were in bloom at the time they were present and special efforts were made to check the feeding habits. Lack of feeding may account for the short duration of the adult stage.

Observations of egg-laying habits were very much in accord with those described by Spencer (1931). However, certain variations were noted and, since these parasites have very unusual oviposition habits, it seems well to record all the observations. There was no direct association between adult parasite and host.

Table 1.—Parasitization of grasshoppers by larvae of nemestrinidae in an area east of Lame Deer, Mont., in 1949.

GRASSHOPPER SPECIES	NUMBERS EXAMINED		PER CENT PARASITIZED		TOTAL
Arphia pseudonietana	101♂	123♀	54.5♂	53.0♀	43.6
Trachyrhachis kiowa	6	11	16.7	63.6	47.0
Encoptolophus sordidus costalis	24	13	12.5	15.4	13.5
Hadrotettix trifasciatus	7	3	14.3	0	10.0
Melanoplus femur-rubrum	43	37	4.7	11.0	7.5
Spharagemon collare	22	32	4.6	6.2	5.6
Ageneotettix deorum	77	114	0	7.0	4.0
Phoetaliotes nebrascensis	68	58	3.0	3.4	3.2
Melanoplus keeleri luridus	60	45	0	4.4	2.0
Melanoplus dawsoni	120	107	0	0	0
Miscellaneous (14 other species)	106	90	3.0	5.6	4.0

The female flies simply congregated on wooden posts, or any other upright objects in the general area of their emergence, for the sole purpose of oviposition. The eggs were deposited in cracks and especially in old holes left by wood-boring beetles. The females were not easily disturbed while ovipositing and could be readily picked off the posts by hand. Some of the populations observed must have been considerably higher than those seen by Spencer, as it was not uncommon to find 50 to 75 flies on a post, 126 being the highest count made. A photograph of females ovipositing on a small portion of a fence post is reproduced in figure 1. Innumerable eggs were laid in the cracks and crevices of the camera during 15 or 20 minutes while several pictures were being taken. Nine eggs were deposited within a few seconds in the fold of a leather jacket worn by a worker. In areas where pine trees were present, eggs were deposited in old beetle holes, in cracks, and under loose bark of trees. At one rather isolated pine tree flies were so numerous they sounded almost like a swarm of bees.

One female was ovipositing in a crack of a post and the eggs could be seen dropping out as fast as they were laid. During the 2-minute observation 198 eggs were laid. In each of 5 subsequent counts of 1 minute each, between 95 and 100 eggs were laid. This female laid over 1000 eggs in 12 to 15 minutes. Another female placed in a pill box at 3:30 P.M. and examined at 10:30 P.M. had laid slightly over 4700 eggs during that interval.

The eggs are about 0.5 millimeter in length and of a light cream color. They hatch in 8 to 10 days at room temperature. A few eggs were held in refrigeration for 20 days at approximately 45° F. with no apparent deleterious effect on hatching or on the vitality of the larvae.

Newly hatched larvae are about the same length and color as the eggs. Larvae retained indoors in dry pill boxes generally survived 5 or 6 days, but some of them lived 2 weeks. In the field larvae were never seen congregated on the posts. Apparently they were scattered by the wind soon after they crawled out of the cracks. Their small size makes them especially adaptable to wind dispersal. Six rather prominent caudal hairs may facilitate this air-borne movement. It is conceivable that they could be carried long distances on even a moderate wind.

The way in which the nemestrinid larvae enter the host is not definitely known. In a number of observations to determine this point the larvae were followed until they disappeared fron sight in the intersegmental folds of the abdomen or in the vicinity of the coxae. It was assumed that they were capable of penetrating this tissue, thus gaining access to the body cavity, but none were actually seen piercing the tissue. Several larvae were seen working at a spiracle, but seemed unable to gain an entrance. The movements of the larvae on the surface of the grasshopper were very erratic, showing no apparent sense of orientation. It took 15 to 30 minutes or longer for larvae placed on the host to disappear from sight into the folds of the tissue.

The larvae of *Trichopsidea clausa* are so small that once they enter the host they cannot readily be found again until they construct their respiratory tubes and attain a length of 2 or 3 millimeters. Then they can sometimes be found by first locating the respiratory tube, which is more sharply defined in the host tissue

than the larvae themselves. By the time a larva reaches maturity it fills a large portion of the abdominal cavity of the host. Observations to date have shown only one living nemestrinid per grasshopper. Rarely a second parasite has been found, but it has always been dead. The larvae feed on the ovaries or testes of the grasshopper. In all grasshoppers infested with *T. clausa* these organs were found to be completely destroyed. Other body tissue is consumed as the larvae approach maturity. Shulov (1948) reporting on a single specimen, said it was "feeding on the testes and the surrounding adipose tissue." However, Potgieter (1929) reported that the eggs within the grasshopper *Locustana pardalina* (Wlkr.) were not destroyed by the nemestrinid he observed. In hundreds of examinations, the authors have never found fully developed eggs in the host when a *T. clausa* larva was present. In fact, small *T. clausa* larvae previously overlooked have often been located after the disorganized and mushy appearance of the grasshopper's ovaries was noted. Whether *Neorhynchocephalus sackeni* larvae are equally effective in destroying their hosts' reproductive potential was not determined.

Upon reaching maturity the larvae force their way through the body wall of the grasshopper and almost immediately enter the soil. Emergence most frequently occurs at the junction of the thorax and abdomen just behind the posterior femur adjacent to the coxa, although occasionally larvae have been seen to emerge dorsally, between the head and thorax. Figure 2 shows a nemestrinid larva emerging from the connective tissue near the coxa of a grasshopper's hind femur. The larvae work their way an inch or two below the soil surface, where they pass the winter. They pupate in the spring. After several weeks the pupa works its way to the surface and the adult emerges. There is only one generation a year.

Grasshoppers live until the parasite larvae emerge from them, and some even survive for a time afterward. In dissections of grasshoppers it is not uncommon to find some with practically hollow abdominal cavities and the molted respiratory tube of the emerged parasite larva still intact.

LABORATORY REARING.—Nemestrinid larvae were collected as they emerged from grasshoppers in the field and were brought to the laboratory for rearing. They withstood considerable handling without apparent harmful effects. Some of them were exposed to the air for several days and when placed on moist soil they burrowed down almost immediately. Some movement within the tunnels was noted when specimens were placed in glass containers where they could be observed. Other specimens put on loose dry soil, where they were unable to form tunnels, continued to move about over the surface for over a month. When transferred to moist, compacted soil, however, a number of them were still able to burrow down into it. The mortality of this group has been rather high though, and as yet none have emerged as adults. Larvae which were permitted to enter compact soil soon after emerging from their host have come through in good condition. These were held in a cool room which was subjected to below-freezing temperatures at various times. After being in this room for about 2 months they were brought into a room having a temperature of 70° to 75° F. Pupation followed within a few weeks.

The pupal period ranged from 10 to 30 days. The pupae work their way to the surface of the soil and move about some before the adults emerge. Movement is made possible by a circular motion of the abdominal portion of the pupae, each segment of which is encircled by a row of spinelike projections, and six longer, hooked seta-like processes. The adult emerges within a few minutes to a few hours after the pupa reaches the surface. Once the pupal case has been split, it is only a few seconds or minutes until the adult is able to free itself. Adults have emerged under dry or moist conditions, but dryness appeared to be slightly more favorable.

Although about 50 adults were reared in the laboratory, no viable eggs were produced. The flies lived only 2 or 3 days. Owing to this short life span and the fact that emergence of a limited number of individuals was protracted for nearly 2 months, males and females were seldom present at the same time. In the few instances when both sexes were present, no copulation was noted. One female laid several hundred eggs, but they soon shriveled and dried. Flies were confined in

screen cages ranging in size from about 8 cubic inches to 8 cubic feet.

HOSTS.—Although the work to determine parasite-host relationship has been rather limited, the following definite rearings were made by the writers in Montana. *Trichopsidea clausa* was taken from *Metator pardalinus* and *Arphia pseudonietana* (Thomas). *Neorhynchocephalus sackeni* emerged from *Encoptolophus sordidus costalis* (Scudd.), *Melanoplus mexicanus* (Sauss.), *Melanoplus alpinus* (Scudd.), *Melanoplus dawsoni* (Scudd.), and *Melanoplus infantilis* (Scudd.).

In the dissection of miscellaneous grasshoppers for determining parasitization, several other species were found infested. Since it was not possible to separate the larval stages of the two species of parasites, it must suffice to say only that the following grasshopper species were infested by nemestrinids: *Ageneotettix deorum* (Scudd.), *Camnula pellucida* (Scudd.), *Hadrotettix trifasciatus* (Say), *Melanoplus keeleri luridus* (Dodge), *Phoetaliotes nebrascensis* (Thomas), *Spharagemon collare* (Scudd.), *Trachyrhachis kiowa* (Thomas), *M. femur-rubrum* (Deg.). This host list represents only the findings to date and is undoubtedly incomplete.

PER CENT OF PARASITIZATION.—To determine parasitization, grasshoppers were collected with an insect net, killed in ethyl alcohol, and then pulled apart with the fingers. In some instances where it was known that the nemestrinids would be very small, the binocular microscope was used and the body contents of the grasshoppers were carefully probed with dissecting needles. Even this method was considered unreliable for finding all the tiny larvae. As development progressed, the maturing parasite larvae could be readily detected without the use of the microscope.

The initial work of dissecting grasshoppers in 1949 was started to gain some idea of the degree of infestation by sarcophagid parasites. The first examination near Colstrip, Mont., on July 13 showed no sarcophagids. Nemestrinids, however, were fairly abundant in *Metator pardalinus*. Parasitization was 24 per cent in the males and 31 per cent in the females. Two other species, *Melanoplus mexicanus* and *Amphitornus coloradus*, were 4 per cent parasitized. Three other species of grasshoppers in the area were not parasitized, but the numbers examined were too small to prove that they might not be subject to attack. No further examinations were made in this area to determine the parasitization, but casual observations in relation to other work indicated an even higher percentage as the season progressed.

Table 2.—Per cent parasitization of *Metator pardalinus* by *Trichopsidea clausa* at Colstrip, Mont.

DATE	GRASSHOPPERS EXAMINED		PER CENT PARASITIZED	
1949				
July 13	79 ♀	62 ♀	24 ♂	31 ♀
1950				
Aug. 1	50	50	46	22
10	0	55	—	76
12	136	108	37	80
25	46	67	39	57

Later in the season additional work was carried on in the mountainous area east of Lame Deer, Mont. The results are shown in table 1. It may be noted that only two species, *Arphia pseudonietana* and *Trachyrhachis kiowa*, were heavily parasitized. On the other hand, only one species, *Melanoplus dawsoni*, was free of the parasite. Of course, some of the 14 species listed as miscellaneous might have been free also, but the numbers involved were too small to be considered reliable for the separate species. Limited work in this same area in 1950 showed 50 per cent of the *Camnula pellucida* to be parasitized.

In 1950 additional data were obtained on parasitization. In the area near Colstrip adult flies were very numerous, as had been anticipated. Nemestrinid larvae were first noted in moderate abundance in grasshoppers on August 1, but even at that time many were rather small and it was believed that some were being overlooked. On August 10 another collection was made, and the examination of the female *Metator pardalinus* showed 76 per cent infested. It was thought this might be too high, possibly owing to selective

Table 3.—Parasitization of grasshoppers by nemestrinid larvae at Bozeman, Mont., on September 26, 1950.

SPECIES	GRASSHOPPERS EXAMINED		PER CENT PARASITIZED	
Melanoplus mexicanus	182 ♂	201 ♀	1 ♂	5 ♀
Melanoplus dawsoni	25	36	0	11
Arphia pseudonietana	21	6	0	0
Encoptolophus sordidus	10	11	0	0

sampling, so another collection was made on August 12. The results verified the findings of the previous collection, showing 80 per cent of the females parasitized. At this time larvae were beginning to emerge from their hosts. On August 25, when another collection was taken, the per cent of parasitization had dropped, owing to emergence of larvae and consequent mortality of the grasshoppers. The records for the collections at Colstrip are given in table 2. During the period when adult flies were present at Colstrip only those of *Trichopsidea clausa* were seen. Furthermore, all specimens reared from *M. pardalinus* were this species.

The high percentage of parasitization which had built up by August 10 and 12 indicates that this is an important parasite for holding *Metator pardalinus* in check, especially when it is realized that parasitized grasshopper females are incapable of egg production.

A collection of grasshoppers was taken near Bozeman, Mont., on September 26. This was rather late in the season and the main parasite emergence had probably taken place sometime previously. The species and per cent of parasitization are given in table 3. It may be noted that females of *Melanoplus dawsoni* were infested, whereas at Lame Deer (Table 1) the parasites were not recorded from this species.

SUMMARY.—Two species of Nemestrinidae (Diptera) that parasitize grasshoppers were studied. The life history and habits of the two species were similar. Flies emerged from pupae that had overwintered in the soil at the time when early developing grasshoppers were in the first and second instars. Eggs were deposited in crevices of fence posts, trees, and other upright objects. The oviposition rate of one female was checked at 95 to 100 eggs per minute. Another female confined in a small pill box laid 4700 eggs in 7 hours. The incubation period was from 8 to 10 days.

Larvae were never seen congregated on oviposition sites, but were presumably scattered by the wind soon after they hatched. The mode of entering the host is not definitely known, but from observations it is believed that the larvae are able to penetrate the connective tissue between the sclerites.

These parasites feed on the ovaries or testes of the grasshopper, but as development progresses they consume other body tissue. No fully developed eggs have ever been found in a parasitized grasshopper.

Fifteen species of grasshoppers were found parasitized in Montana during 1949 and 1950. The percentage of parasitization was variable, the highest thus far noted being 80 per cent in females of *Metator pardalinus* (Sauss.).

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Phytotoxicity of Some Insecticides to Coniferous Seedlings with Particular Reference to Benzene Hexachloride[1]

H. G. Simkover and R. D. Shenefelt[2]

Chlordane and benzene hexachloride have been reported as promising soil insecticides for white grub control in forest tree nurseries by Shenefelt and Simkover (1950). Before they could be recommended, it was necessary to test their possible phytotoxicity to coniferous seedlings. Consequently, all compounds investigated which gave effective white grub control were routinely tested for phytotoxicity in the greenhouse, laboratory, and field. Laboratory trials with DDT, toxaphene, Test Material 1(s(1,2-dicarboethoxyethyl)-dimethyl dithiophosphate), dieldrin, aldrin, parathion, TDE, Test Material 2,(2 parts 2-nitro-1,1-bis-(p-chlorophenyl) butane plus 1 part 2-nitro-1,1-bis-(p-chlorophenyl) propane), dilan, chlordane, heptachlor, and octamethyl at 10 p.p.m. in aqueous solution showed these materials relatively noninjurious to pine root growth. Aldrin and dieldrin at 10 pounds per acre did not produce any phytotoxic symptoms to Norway pine seedlings grown in white sand or Plainfield sand. After greenhouse and laboratory trials showed that both crude benzene hexachloride and lindane induced root abnormalities, detailed investigations were made to characterize the injury and discover the components responsible.

Characterization of Benzene Hexachloride Root Injury.—Freshly germinated Norway pine seedlings were transplanted to white sand treated with benzene hexachloride at the rate of one pound of the gamma isomer per acre. Macroscopic evidence of root tip swelling was first noted 6 days after exposure, and by the tenth day the root tips were twice the normal diameter.

When chromosome smears of the treated root tips were prepared according to the Heitz (1936) squash modification of the Feulgen stain technique, it was found that with progressively longer exposure to benzene hexachloride, the affinity of the nuclei for the stain correspondingly diminished. After three and a half days exposure, the nuclei were hardly discernible. Untreated pine root tips, on the other hand, retained good nuclear staining properties and many mitotic figures were visible. The nuclei of treated root tip cells stained by Rafalko's Feulgen method (Moree 1947) or with methyl green also failed to stain. Since both the Feulgen and methyl green stains are specific for desoxyribosenucleic acid, the failure of the chromosomes to stain indicates that the benzene hexachloride treatment induced cellular changes resulting in the destruction of these nucleic acids.

After several nuclear staining techniques were tried on treated root tip sections, it was found that the nuclei stained well with LaCour's (1937) crystal violet-iodine.

Cytological abnormalities were confined primarily to the meristematic region of the root tip. A decrease in the number of metaphases occurred with increased exposure to benzene hexachloride. The nuclei of some of the cells showed an increase in chromosome number within 4 days after exposure to benzene hexachloride. Typical c-mitotic[3] nuclei were observed in a section of tissue prepared from a root treated for 8.5 days. In these cells the spindles were disrupted, the chromosomes extruded from the nuclei and the chromatid pairs attached only at the centromeres, thus giving chromosomes an X-shaped configuration. Figure 1–6 shows the scattered chromosome arrangement resulting from spindle disruption. With increased exposure to benzene hexachloride, a corresponding increase in the number of multinucleate cells in the meristematic region occurred. Figure 1–7 shows a typical polyploid cell and Figure 1–9 multinucleate cells, while Figure 1–3 shows the normal dividing cells of untreated roots.

[1] Results of a cooperative project between the College of Agriculture and the Wisconsin Conservation Department. Approved for publication by the Director of the Wisconsin Agricultural Experiment Station. Portion of thesis by H. G. Simkover, submitted in partial fulfillment of requirements for Ph.D. degree in Economic Entomology at the University of Wisconsin. Presented at the meeting of the American Association of Economic Entomologists at Denver, Colo., December 21, 1950.

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[3] "c"—meaning colchicine type response.

Short, flat, and discontinuous trachaeid elements, typical of wound xylem, appeared in root tips exposed to benzene hexachloride for 9 days. These abnormal trachaeids were consistently found among the meristematic cells (Figure 1–9) rather than in their normal location in the area of cell differentiation.

In clubbed root tips, cells dividing in several planes were frequently noted. The root tip swellings were attributed to this loss of polarity and the predominance of

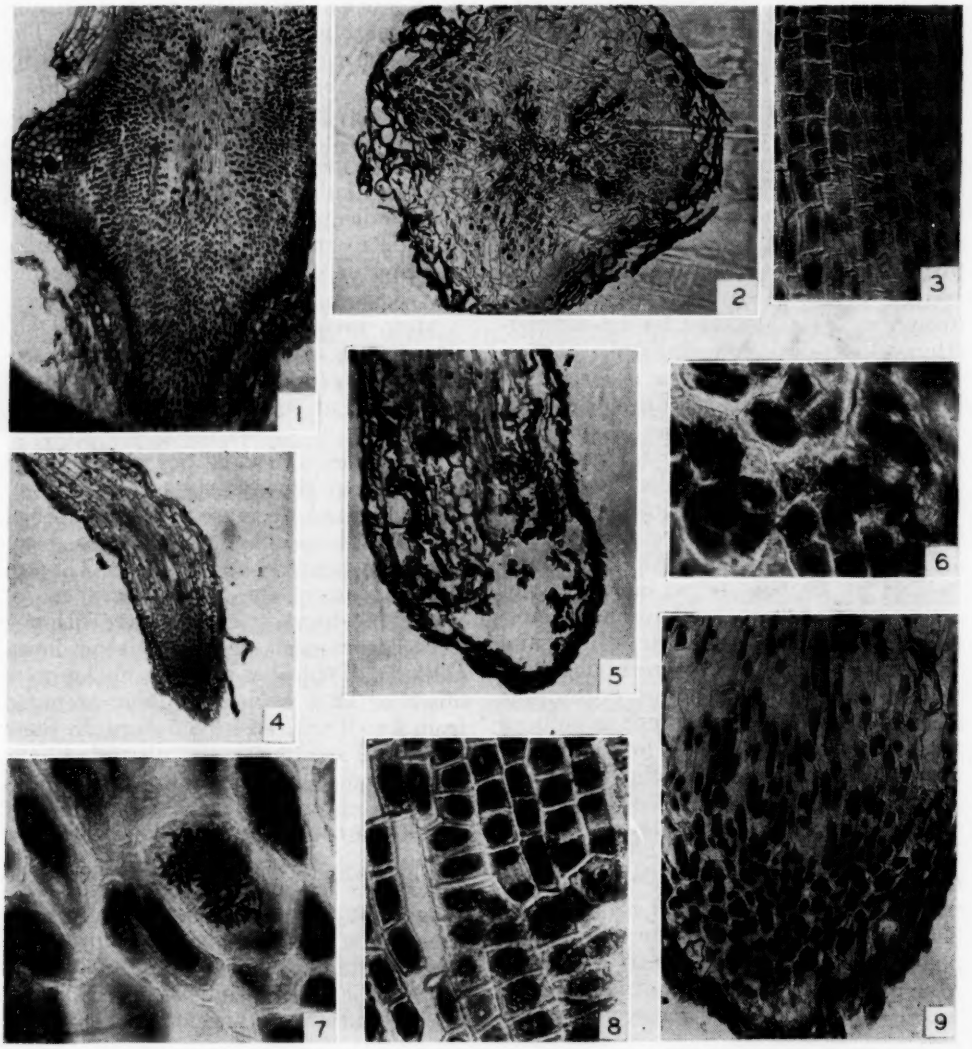

FIG. 1.—Cytological and anatomical effects of crude benzene hexachloride at 1 lb. gamma per acre, pure gamma benzene hexachloride at 1 lb. per acre, and sodium 2,4-D at 10 p.p.m. on Norway pine root tips. 1. Longitudinal section showing stimulation of cell number caused by exposure to sodium 2,4-D at 10 p.p.m. for 7 days. ×35.—2. Cross-section showing root initials in root exposed to benzene hexachloride for 51 days. ×35.—3. Longitudinal section of normal dividing cells in roots exposed to untreated sand for 14 days. ×200.—4. Longitudinal section of root tip grown in untreated sand for 8 weeks. ×35.—5. Longitudinal section showing tissue collapse after 8 weeks exposure to benzene hexachloride. ×35.—6. Longitudinal section showing spindle disintegration and chromosome scattering in root exposed to benzene hexachloride for 10 days. ×400.—7. Longitudinal section of polyploid cell found in root exposed to benzene hexachloride for 14.5 days. ×325.—8. Longitudinal section showing normal dividing cell with spindle fibers and equatorial plate in root exposed to pure gamma benzene hexachloride for 8 weeks. ×375.—9. Longitudinal section showing multinucleate cells and abnormal trachaeids in root exposed to benzene hexachloride for 11.5 days. ×100.

Table 1.—Effect of the vapors of impurities and breakdown products of benzene hexachloride on germination and root growth of Norway pine seedlings 7 days after germination.

Material	Per Cent Germination		Notes on Root Condition
	Rep. 1	Rep. 2	
Crude tetrachlorobenzene	100	100	Aborted, (14 to 25 per cent as long as control), root tips brown, shrivelled and apparently dead.
1,2,3-trichlorobenzene	100	100	Hypocotyl scarcely extending beyond seed coat—no root growth at all.
1,2,4-trichlorobenzene	80	100	Aborted, (14 to 25 per cent as long as control), root tips brown and clubbed.
1,3,5-trichlorobenzene	93.3	86.7	Aborted, (33 per cent as long as control), roots thickened and distinctly clubbed (stems also thickened and needles dwarfed).
Octachlorocyclohexane	100	80	Considerably stunted, (5 to 60 per cent as long as control), roots varied in length from 1 mm. to 12 mm.
Heptachlorocyclohexane solid	80	100	Normal.
Heptachlorocyclohexane oil	100	86.7	Normal.
Crude benzene hexachloride	86.7	86.7	Aborted (33 per cent as long as control), a few roots showed distinct clubbing.
water-Control	100	93.3	Normal, approximately 20 mm. long.

giant nuclei in the meristematic, epidermal and cortical tissues. In some roots, after the club, or c-tumor, was well developed, the meristematic and cortical cells collapsed and tissue disintegration in the apical area followed (Figure 1–5). Figure 1–4, a longitudinal section of an untreated root tip, is included for purposes of comparison. However, other c-tumors developed to a certain size and subsequently formed new root initials (Figure 1–2). These initials, which give rise to secondary roots, were derived from pericycle tissue. The nuclei of the secondary root initials were polyploid.

The action of sodium dichlorophenoxyacetate at 10 p.p.m. was compared to benzene hexachloride. Root tip swelling induced by the former differed from that caused by benzene hexachloride in that the abnormality resulted from stimulation of cell division and formation of secondary initials (Figure 1–1) rather than increase in cell size.

THRESHOLD PHYTOTOXIC CONCENTRATION OF BENZENE HEXACHLORIDE.—Benzene hexachloride mixed into white sand produced injury to pine roots when used at rates in excess of 8 ounces gamma per acre, but in Plainfield sand retardation of root growth was not noted unless dosages of one pound or more per acre were employed. Greater root growth was obtained in white sand with benzene hexachloride at one-eighth and one-quarter pound of gamma per acre than at higher or lower dosages. When Norway pine seedlings were exposed to solutions containing 1 p.p.m. of benzene hexachloride growth was suppressed.

TRIALS WITH ISOMERS, IMPURITIES, AND BREAKDOWN PRODUCTS OF BENZENE HEXACHLORIDE.—When pure alpha, beta, gamma, and delta isomers were mixed into white sand at 1 pound per acre, no evidence was found that any of the isomers was definitely phytotoxic, although there was slight reduction in root weight and length. Samples of plants taken at random from each treatment and the control showed no indication of root abnormality 2 weeks after germination. When sections of the root tips were examined, no cell or tissue injury was found. Normal mitotic figures were observed in the meristematic region of the root tips grown in

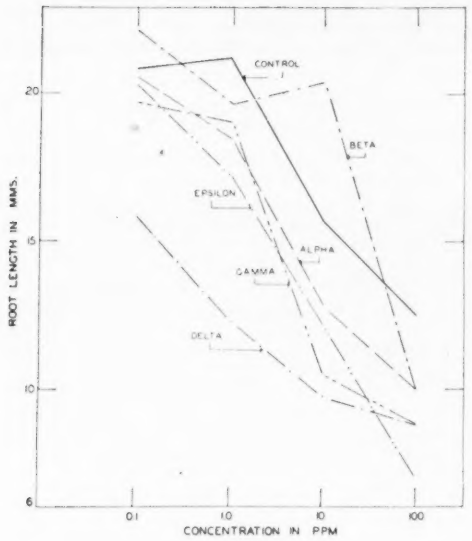

FIG. 2

each treatment. Root tips of seedlings collected 8 weeks after planting showed no abnormalities. Even tissue treated with pure gamma isomer was normal (Figures 1–8), contrary to reports of D'Amato (1949), Kostoff (1949), Nybom & Knutson (1947) and others working with *Allium cepa*.

Figure 2 graphically portrays the results of observations made after 7 days of exposure of freshly germinated Norway pine seedlings to suspensions of the purified isomers of benzene hexachloride. Since the isomers are only very slightly soluble in water, ethanol solutions were prepared and then diluted in water to give the desired concentrations. An ethanol control, similarly diluted with water, was run concurrently with these tests. At 100 p.p.m. all isomers were phytotoxic. However, at the lower concentrations, delta benzene hexachloride was the only one which produced definite inhibition of root growth and distinct root thickening.

Benzene hexachloride breaks down under alkaline conditions to produce a mixture of trichlorobenzenes. When this crude mixture and three of its known trichlorobenzene components[1] were tested in liquid, it was found that all inhibited root growth (Figure 3). The most injurious material was 1, 3, 5-trichlorobenzene followed by 1, 2, 4 and finally by the 1, 2, 3-isomer. This rating differs from that given by

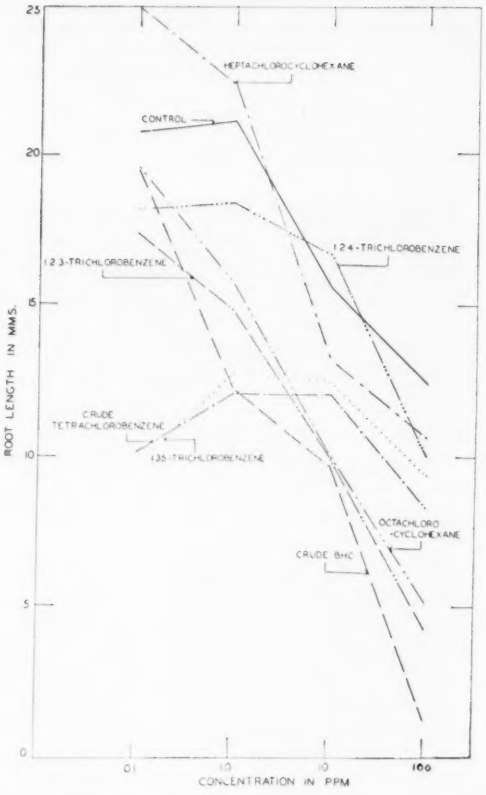

FIG. 3.—Growth of Norway pine seedlings exposed for 7 days to suspensions of hexachlorocyclohexane, octachlorocyclohexane crude tetrachlorobenzene, 1,2,3-trichlorobenzene, 1,2,4-trichlorobenzene, 1,3,5-trichlorobenzene and crude benzene hexachloride at varying concentrations.

Hocking (1950) for wheat seedlings.

Heptachlorocyclohexane and octachlorocyclohexane, two of the impurities found in crude benzene hexachloride, showed less tendency to inhibit pine root growth than crude benzene hexachloride itself (Fig. 3). Of the two, octachlorocyclohexane was the more toxic.

Since benzene hexachloride, its impurities, and its breakdown products have a high degree of volatility, tests were made of the effects of the vapors on germination and growth of pine seedlings. The results have been summarized in Table 1. All the trichlorobenzene isomers were active in the vapor phase, while of the impurities, octachlorocyclohexane alone caused root injury. None of the materials tested appreciably inhibited germination. The vapor

[1] Prepared by the Terre Haute Laboratory of Commercial Solvents Corp.

of crude benzene hexachloride inhibited root growth and produced typical clubbed roots in several of the seedlings. This is contrary to the results of Kostoff (1949).

INHIBITION OF PHYTOTOXIC ACTION OF BENZENE HEXACHLORIDE.—Soil particle size and pH exercised little influence on the capacity of benzene hexachloride to induce root malformations in Norway pine. However, when peat was added to white sand at 25 per cent by volume (2.4 per cent organic matter on a dry weight basis), the effects of benzene hexachloride at one pound of the gamma isomer were no longer manifested. The mineral ash, ether and hot water extracts, and extract residues of peat did not prevent injury or slow down the rate of development of abnormalities. Investigations to find some possible chemical inhibitor of benzene hexachloride injury have shown that none of the materials tested, with the possible exception of biotin, possessed the capacity to overcome the undesirable effects of benzene hexachloride on pine roots.

CHLORDANE.—No root injury to Norway pine seedlings was detected when chlordane was mixed into Plainfield sand at dosages as high as 100 pounds per acre. At no time did any of the plants grown in the chlordane treated soil exhibit any depression of vigor or root growth when compared to the control. In fact, it actually appeared that the chlordane treatment up to the 50 pound per acre level was somewhat beneficial to pine growth.

EFFECTS OF BENZENE HEXACHLORIDE AND CHLORDANE ON SOME SPECIES OF TREE SEEDLINGS.—Although most of the 20 species of conifers exposed to soil treated with benzene hexachloride at 1 pound of gamma per acre showed root malformations, they differed in degree of susceptibility to this insecticide. This is in general agreement with the present belief that closely related plants and even varieties may respond differently to a particular insecticide (Cullinan 1949; Matthewman *et al.* 1950; Foster 1950 and others).

None of the conifers were affected by chlordane at 10 pounds per acre, but black locust showed slight depression of vigor 8 weeks after planting.

SUMMARY.—The anatomical and cytological abnormalities induced by benzene hexachloride in pine roots have been described.

As little as one p.p.m. of crude benzene hexachloride and 8 ounces of gamma (in crude benzene hexachloride) per acre in solution and in white sand, respectively, is sufficient to incite root malformation in Norway pine seedlings.

The trichlorobenzene breakdown products of benzene hexachloride were the most injurious components when tested as vapors or in solution.

The addition of 2.4 per cent (by weight) organic matter to white sand offset the phytotoxicity of benzene hexachloride at one pound of the gamma isomer per acre.

Chlordane was found to be non-phytotoxic to 20 species of conifers and dosages as high as 100 pounds per acre did not injure Norway pine seedlings in Plainfield sand.

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Spray versus Dust for Boll Weevil Control with Ground Equipment

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The recent development of inexpensive low-pressure sprayers has stimilated considerable interest in concentrated sprays for cotton insect control.

Tests were conducted at Florence, S. C., during 1949 to compare the effectiveness of concentrated emulsion sprays and dusts for the control of the boll weevil, *Anthonomus grandis* Boh.

Materials.—Only emulsion concentrates were used, diluted with water to the desired strength. The concentrates were obtained directly from the manufacturers and the formulations supplied by them are given in table 1. Most of the dusts were mixed by the manufacturers in strengths suitable for application. The dust containing 20 per cent of toxaphene and 10 per cent of DDT was prepared in the laboratory by diluting with pyrophyllite dusts containing 40 per cent of toxaphene and 50 per cent of DDT.

Field Plots.—Large-scale experiments were conducted in six fields. The plots were 24 rows wide in five fields and 16 rows wide in the other field. The plots extended for the full length of the field and ranged from 0.67 to 1.27 acres.

These plots, dusted and sprayed with the same materials, were adjacent to each other in every field. Eight of the eleven treatments were replicated in three separated fields, but none of the treatments were replicated in the same field.

With one exception, there was an untreated plot on each side of each field, and the data from these two plots were averaged in comparing the results with those of the treated plots.

Equipment.—A 4-row horse-drawn sprayer[3] was used. The pump was operated by a 15-horsepower motor mounted on a platform 42 inches above ground.

The sprayer was equipped with three conical T-jet nozzles per row, one placed 6 to 8 inches directly above the plants and one on each side of the row. The nozzle had an orifice diameter of 0.039 inch with a capacity of 0.079 gallon per minute at 60 p.s.i. and a spray angle of 75°.

The pump was a bronze rotary-gear type. It was operated at 60 pounds pressure throughout the season, thus providing sufficient spray to give 4 gallons per minute of overflow through the by-pass of the pump for agitation. With a 5-gallon spray tank this overflow was sufficient to keep the emulsion well mixed.

The spraying system contained three fine screens, one in the spray tank, one just in front of the pump, and one inside the nozzle. At the end of each day's operation water was pumped through the system to clean it, and little trouble from clogging of the nozzles was encountered throughout the season.

The machine delivered 8.6 to 9.8 gallons of spray per acre-application regardless of the formulation.

A 4-row horse-drawn power duster[4] was used for applying the dusts. It was operated by a 15-horsepower motor mounted on a platform 42 inches from the ground. One nozzle was placed directly above each row. On the average, 11 pounds of dust of each formulation was used per acre-application.

Application of Insecticides.—Seven applications of both dusts and sprays were made in experiments 1, 2, and 3, and six in experiment 4. These applications were made between June 14 and August 1.

The dusts were applied between 5 and 7 A.M., when the plants were wet with dew and the air was fairly calm.

The sprays were applied between 9 A.M. and 5 P.M. regardless of wind velocity, and on the same dates that the dusts were applied.

All formulations were applied at about 5-day intervals throughout the season.

Approximately the same amount of active ingredient was applied per acre-application in both the dust and spray formulations of each toxicant. The proportion of emulsion concentrate to water in the spray mixture, the per cent of active ingedients in the dusts, and the aver-

[1] Floyd F. Bondy deceased July 19, 1950.

[2] In cooperation with the South Carolina Agricultural Experiment Station.

[3] Furnished through the courtesy of the Sherwin-Williams Company.

[4] Furnished through the courtesy of the Messinger Manufacturing Company.

Table 1.—Formulations of emulsion-concentrate sprays as reported by manufacturers. Florence, S. C., 1949.

Emulsion Concentrate	Toxicant		Solvent		Per Cent of Emulsifying Agent
	Pounds per Gallon	Per Cent	Type	Per Cent	
Chlordane plus DDT	4 +2	38.3+19.2	*Velsicol AR-50*	34.5	8
Toxaphene plus DDT	4 +2	40 +20	Aromatic petroleum	30.0	10
Benzene hexachloride plus DDT	0.96[1]+1.6	36 +16.7	Alkylated aromatic	50.5	5
Toxaphene	4	42.0	Petroleum hydrocarbon	45.0	10
Aldrin	4	52.0	Xylene-Standard Oil #10	33.0	15
Dieldrin	2	25.0	Aromatic petroleum	65.0	10

[1] Gamma isomer.

age dosage per acre-application for each formulation are shown in table 2.

Boll weevil infestation records were made at weekly intervals until the crop was mature. Records were also made on the number of aphids, bollworms, and red spider mites, but none were numerous enough to materially influence the results in any of the tests. Yields were determined by harvesting 0.162 to 0.376 acre per plot.

FIELD CONDITIONS.—The rainfall was 3.37 and 3.68 inches in June and July. Drought caused heavy shedding of the squares and small bolls, and as a result the yields were greatly reduced in all plots. These conditions also aided in the natural control of the boll weevil.

The rainfall in August was 9.55 inches, or 4.86 inches above normal. To prevent boll rot, all the plots in four fields were defoliated with about 20 pounds per acre of cyanamide dust.

RESULTS.—*Toxaphene dust versus spray.*—Both of these formulations gave good boll weevil control when applied at the rate of about 2.2 pounds of active ingredient per acre-application. There was little difference between the dusted and the sprayed plots (Table 3).

Based on an average of three tests, the spray produced 65 pounds of seed cotton per acre more than the dust, ranging from −2 to 109 pounds. The gains in yield over the check, were 383 and 448 pounds per acre for the dust and spray, respectively.

Toxaphene plus DDT dust versus spray.—These toxicants were applied at the rate of 2.2 to 2.4 pounds of technical grade of toxaphene and 1.09 to 1.2 pounds of DDT per acre-application. Both the spray and the dust gave good boll weevil control (Table 3).

The sprayed plots consistently yielded more seed cotton than the dusted plots, ranging from 19 to 212 pounds per acre and averaging 104 pounds.

The gains in yield over the check plots were 514 and 410 pounds per acre for the sprayed and dusted plots, respectively.

Chlordane plus DDT dust versus spray.—Both the spray and dust gave good boll weevil control when applied at the rate of about 1.1 pounds of actual chlordane and 0.55 pound of DDT per acre-application.

Based on an average of three tests, the sprayed plots produced 133 pounds of

Table 2.—Formulation and application of dust and spray mixtures for boll weevil control, Florence, S. C., 1949.

Insecticides	Spray Mixture		Active Ingredients in Dust Mixture	Rate per Acre Application[1]	
	Concentrate	Water		Spray	Dust
	Pints	*Pints*	*Per Cent*	*Pounds*	*Pounds*
Toxaphene plus DDT	5.0	75.0	20+10	2.27+1.13	2.28+1.14
Chlordane plus DDT	2.5	77.5	10+ 5	1.15+0.57	1.03+0.52
Benzene hexachloride plus DDT	3.0	77.0	3[2]+ 5	0.33+0.55	0.32+0.54
Toxaphene	5.0	75.0	20	2.20	2.19
Aldrin	1.25	78.75	—	0.55	—
Dieldrin	0.75	79.25	1.5	0.15	0.17

[1] Active ingredients. [2] Gamma isomer.

Table 3.—Boll weevil infestation and yields of seed cotton in large field plots treated with various organic insecticides as dusts and sprays. Florence, S. C., 1949.

Experiment No.	Per Cent Punctured Squares			Seed Cotton per Acre			Gain, Spray Over Dust
	Check	Dust	Spray	Check	Dust	Spray	
			Toxaphene				
1	30	14	10	715	1082	1191	109
3	14	11	15	877	1224	1222	− 2
4	43	6	4	774	1210	1298	88
Average	29	10	10	789	1172	1237	65
			Toxaphene Plus DDT				
2	53	15	17	767	1474	1494	19
3	14	8	11	877	1232	1311	79
4	43	10	18	774	944	1156	212
Average	37	11	15	806	1216	1320	104
			Chlordane Plus DDT				
1	30	5	15	715	754	1104	350
3	14	10	14	877	1202	1149	− 53
4	43	8	6	774	1139	1243	104
Average	29	8	12	789	1032	1165	133
			Benzene Hexachloride Plus DDT				
1	30	7	5	715	1145	1219	74
2	53	14	23	767	1535	1329	−206
4	43	6	8	774	1209	1088	−121
Average	42	9	12	752	1296	1212	− 84
			Dieldrin				
6	57	9	13	953	1788	2075	287
			Aldrin				
4	43	—	10	774	—	1208	—

seed cotton per acre more than the dusted plots, ranging from −53 to 350 pounds (Table 3). The gains over the untreated check plots were 243 and 376 pounds for the dusted and sprayed plots, respectively.

Benzene hexachloride plus DDT dust and spray.—Both formulations of dust and spray were applied at the rate of about 0.33 pound of gamma benzene hexachloride and 0.54 pound of DDT per acre-application. Good boll weevil control was obtained with both materials.

An average of three tests showed that the dusted plots produced 84 pounds of seed cotton per acre more than the sprayed plots, ranging from −74 to 206 pounds (Table 3). The gain over the untreated check plots averaged 544 and 460 pounds per acre for the dusted and sprayed plots, respectively.

Dieldrin.—Both the dust and the spray formulations of dieldrin gave excellent control of the boll weevil at 0.15 and 0.172 pound of the active ingredient per acre-application. Treatments were begun at 30 per cent square infestation, eight applications being made between June 28 and August 1. The seasonal square infestation in the sprayed and dusted plots averaged 13 and 9 per cent; the check, 57 per cent.

Yields over the untreated plot were higher than for any of the other formulations tested. The yields of seed cotton per acre were 2075 and 1788 pounds for the sprayed and dusted plots; the check yielded 953 pounds. The sprayed plot produced a gain of 1122 pounds per acre, or 287 pounds more than the dusted plots (Table 3).

Table 4.—Boll weevil infestation and yield of seed cotton in plots treated with toxaphene or toxaphene plus DDT. Florence, S. C., 1949.

Experiment No.	Per Cent Squares Punctured			Seed Cotton per Acre (lbs.)			Gain, DDT Over no DDT
	Check	With DDT	Without DDT	Check	With DDT	Without DDT	
				Toxaphene Spray			
3	14	11	15	877	1311	1222	67
4	43	18	4	774	1156	1298	−142
5	48	15	20	538	1010	943	89
Average	35	15	13	730	1159	1154	5
				Toxaphene Dust			
3	14	8	11	877	1232	1224	8
4	43	10	6	774	944	1210	−266
Average	29	9	8	826	1088	1217	−129

Aldrin.—Only the spray formulation of aldrin was used, and it was applied at the rate of 0.55 pound of active ingredient per acre-application.

Good boll weevil control was obtained, the seasonal infestation averaging 10 per cent for the treated plot and 43 per cent for the check plot (Table 3).

The treated plot yielded 1208 pounds of seed cotton per acre, or a gain of 434 pounds over the untreated check.

Toxaphene versus toxaphene plus DDT.—For weevil control there was no advantage in adding DDT to toxaphene, either as a dust or a spray (Table 4).

All these formulations gave good boll weevil control and good increases in yield.

Phytotoxicity.—None of the various dust or spray formulations used in these experiments caused any commercial injury to the cotton plant.

SUMMARY.—Spray and dust formulations of chlordane plus DDT, toxaphene plus DDT, benzene hexachloride plus DDT, toxaphene, dieldrin, and aldrin were tested in large field plots for boll weevil control during 1949 at Florence, South Carolina.

The dusts were applied at about 11 pounds per acre-application and the sprays at approximately 9 gallons.

Thus dusts and sprays were applied with 4-row horse-drawn equipment powered by 1.5 horsepower motors mounted on a platform about 42 inches above the ground. Approximately the same amount of active ingredients was applied per acre in both the dust and spray for each formulation tested.

Both the dusts and sprays of all formulations gave good boll weevil control and good increases in yield of seed cotton. Dieldrin, in both the dust and spray, was the most outstanding material tested.

Based on an average of three large field tests, the plots sprayed with chlordane plus DDT, toxaphene plus DDT, and toxaphene produced slightly higher yields than the dusted plots. With benzene hexachloride plus DDT, however, the dusted plots outyielded the sprayed plots.

For boll weevil control there was no advantage in adding DDT to toxaphene, either as a dust or as a spray.

None of the various dust or spray formulations used in these experiments caused any commercial injury to the cotton plant.

From the standpoint of boll weevil control, cost of materials and equipment, and the possibility of making spray applications in conjunction with tractor cultivation, low-gallonage spraying shows excellent promise.

Observations on the Behavior of the Webbing Clothes Moth

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The U. S. Army Quartermaster Corps is interested in the improvement of methods for detecting and controlling insects which damage military items. At present there appears to be no effective method in use for trapping clothes moths, although female clothes moths (species undetermined) have been trapped using fish meal, alcoholic extracts of fish meal, or dried animal tissue with a strong odor, as an attractant (Wilson 1940). Apparently no artificial attractants for male clothes moths have been reported. The observations of Titschack (1922) on the mating behavior of the webbing clothes moth indicated that the males are attracted to the females by an odorous substance. The present paper is the result of a search for naturally occurring attractants for *Tineola biselliella* (Hum.).

It has long been known that odor is important in sex attraction of many insects. This is particularly true among certain Lepidoptera, the females elaborating scents which attract the males of the species, sometimes from great distances. Males of *Arctias selene* oriented to the female from a distance of 6.8 miles (Mell 1922), and some males of *Porthetria dispar* (L.) were attracted to the female from as far away as 2.3 miles (Collins & Potts, 1932). Sex attractants have been used in the field to trap male moths (Collins & Potts 1932; Götz 1939a, 1939b), and though this practice has been of little value in controlling a species, it has been of considerable help in locating newly infested areas (Collins & Potts 1932; Burgess 1950).

Much work has been done on the morphology of the scent producing apparatus of moths (Freiling 1909; Richards 1927; Dickins 1936; Barth 1937a). Both sexes of moths possess scent glands which are usually found associated with specialized scent scales that disseminate the odor. The male scent supposedly acts as an aphrodisiac that stimulates the female to copulate, while the female scent attracts the male. In many instances the female liberates the scent when she takes up a characteristic "calling pose" at which time the tip of her abdomen projects between her wings; this may be accompanied by an alternate protrusion and retraction or "pulsation" of the ovipositor (Kettlewell 1946).

OBSERVATIONS AND EXPERIMENTS.—Both male and female clothes moths may be seen at rest with their wings raised vertically above the thorax. This is a post-emergence position and should not be confused with any phase of mating behavior. This attitude is assumed by an individual about 10 to 15 minutes after it has emerged from the pupal skin; the wings may be kept in the vertical position for 5 to 20 minutes.

A sexually active male walks about rapidly and erratically, continually vibrating or fluttering his wings (courting response; Fig. 1,2) and with his abdomen extended slightly dorsad. Males may show this behavior about 4 hours after emergence. When the male approaches a female he may stand in front of her, to one side, or behind her during which time he continues to vibrate his wings. After touching the female the male flexes his abdomen sideways (clasping response; Fig. 1, arrow) and attempts to grasp her genitalia. After making connection the male moves around so that the insects are in a linear position (Fig. 1). At this time the apices of the male's wings usually rest over those of the female. The pair remain in copula from 12 to 18 minutes; the mean duration of 10 copulations was 15 minutes. One male was observed courting a female about one hour after he had copulated. Males are often attracted to copulating pairs of moths (Fig. 1,1).

The female appears inactive during the male's maneuvers and at first the calling pose was not observed. However, with the aid of a dissecting microscope and with a mirror placed under the insect, females have been seen on several occasions to protrude and retract the ovipositor. This movement is not noticeable from above since the tip of the abdomen is hidden by the wings. The female may also extend her abdomen dorsad so that the tip of her ovipositor protrudes slightly between and above the wings. When in this position the tip of the ovipositor can be seen to vibrate. This behavior is similar to the calling pose described for other female moths.

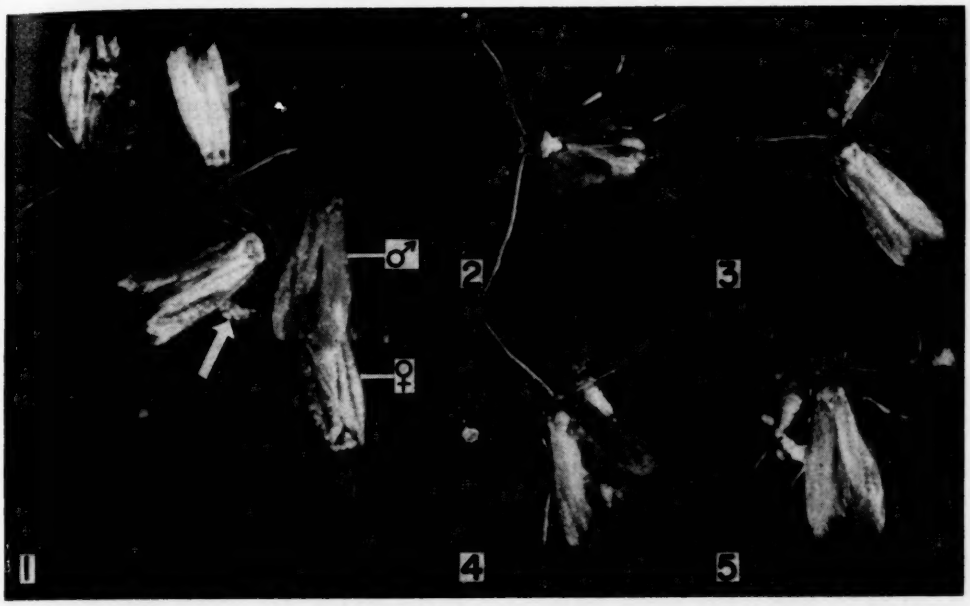

FIG. 1.—Sexual behavior of males of *Tineola biselliella*. (1) Four males attracted to a copulating pair (♀ and ♂ symbols) of moths. Note the male with his abdomen (arrow) flexed to one side (clasping response), attempting to grasp the female. (2) Male fluttering his wings in the courting response. (3) Male attracted to an isolated female abdomen. (4) Male courting the isolated female abdomen. (5) Male flexing his abdomen and attempting to grasp the tip of the isolated female abdomen (clasping response).

Titschack (1922) noted that after a female had been stimulated by a male and become separated from him she would raise her abdomen and protrude the ovipositor.

The following experiment was performed to determine which part of the female gives off the odorous attractant. The abdomen of a 1-day old female was severed from the rest of the body. The head and thorax (wings and legs attached) were placed about 1 to 2 mm. from a quiescent male in a 5 cm. petri dish. If the male failed to court within 5 minutes, the head and thorax of the female were removed and her severed abdomen was placed near the male. In all trials the female head and thorax were presented first. The results of 40 trials with 40 different males were as follows: 2 males responded to the head and thorax; 32 males responded to the female abdomen (the average time taken for these males to respond was 42 seconds); 6 males failed to respond to any part of the female. It is apparent that the odorous attractant of the female is present on her abdomen and probably originates near the ovipositor as has been described in other moths (Dickens 1936). Figures 1,3 to 1,5 show the response of a male to an isolated female abdomen. A few males made genital connection with the severed female abdomen. Males which had been activated by the female abdomen gave a clasping response on coming in contact with the isolated female head and thorax. An isolated female abdomen kept at room temperature loses its attractiveness for the male within 24 hours or less.

A single isolated female abdomen will activate a quiescent male from a distance of about 1.5 cm. Males could be activated and attracted to 10 severed female abdomens from a distance of 7 cm. (in these tests the males responded within 1 minute or less). The males of *Bombyx mori* (L.) are responsive to female scent from a distance of 3 to 5 cm. (Chen & Young 1943).

The following experiment was performed to determine the ability of the male to discriminate between the male and female abdomen. Severed abdomens of both sexes were impaled on dissecting needles and brought to about 1 to 2 mm. from the antennae of the test males in 5 cm. petri dishes. The males were given a time limit of 15 seconds in which to respond. The results with 56 different males were

Table 1.—Attraction of males of *Tineola biselliella* to isolated female abdomens. (Tests were performed in a dimly lighted room with the moths kept in chambers 23 to 24.5 cm. in diameter. The severed abdomens of 5 virgin females were used as the attractant. The test males had been isolated from females for several days.)

Experiment	Observation Period (minutes)	Behavior of Males at Introduction of Female Abdomens	Males in Chamber	Males Attracted to Female Abdomens
1[1]	15	little activity; several males courting	38	27 (71%)
2	15	inactive	35	29 (83%)
3	15	majority active and courting	25	23 (92%)
4	30	majority active and courting	25	18 (72%)
5	30	inactive	30	24 (80%)
6	30	inactive	45	19 (42%)

[1] In this experiment the males were first exposed to five isolated male abdomens. During a 15-minute observation period only three males were observed attempting to copulate with the male abdomens.

as follows: none of the males responded to an isolated male abdomen; 50 males responded to the female abdomen; 6 males failed to respond to either stimulus.

Since males can be seen courting and attempting to copulate with other males in the absence of females, the question is raised as to whether or not a male can discriminate between males and females. The following experiment was performed: pairs of virgin males were placed together in 5 cm. petri dishes and their behavior towards each other was observed for a 5-minute period. If no courting occurred during this period, a 1-day old virgin female was introduced and the behavior of the males was again noted. The results with 20 different pairs of males were as follows: in 2 trials the males courted in the absence of a female; in 18 trials one or both males courted only after the introduction of a female (the average time taken for the males to start courting was 18 seconds after introduction of the female). This experiment shows that although a male may court in the presence of another male, the male is more frequently aroused by the presence of the female and in this sense can discriminate between the sexes.

From the foregoing observations and experiments it can be concluded that males of *Tineola* may be found in the following states: (1) sexually active in the absence of the female; (2) sexually active in the presence of the female; (3) sexually inactive in the presence of a female; (4) sexually inactive in the absence of a female but capable of being stimulated to court by the introduction of a female or the abdomen of a virgin female; (5) sexually inactive and incapable of being stimulated sexually by a female abdomen (in these cases the female abdomen was stimulating to other males).

Several experiments were performed in which males were exposed to the isolated abdomens of several females in large, moist chamber dishes which were covered with glass plates that had small openings in the center. The males were removed from the chamber with an aspirator after they had been attracted to and had attempted to mate with the centrally placed, isolated, female abdomens. The results of these experiments are shown in table 1. It can be seen that males can be attracted to isolated female abdomens in chambers 23 to 24.5 cm. in diameter. In experiment 4, 48 per cent of the males were attracted during the first 10 minutes of the observation period; between 10 and 19 minutes from the start of the test the remaining moths were inactive; between 19 and 23 minutes the males became active again and 24 per cent (of the original 25 males) were removed after they attempted to mate with the female abdomens. In experiment 5, the first moths began to court 40 seconds after introduction of the female abdomens. Shortly afterwards most of the moths were courting and were attracted within 10 minutes after the start of the experiment. After 11 minutes the remaining moths became quiet and remained so for the rest of the observation period. In experiment 6, the first moths became active 2 minutes after introduction of the female abdomens; 38 per cent of the males were attracted during the first 15 minutes of the experiment.

Two additional experiments of this kind were performed in which the attractant was a crude petroleum ether extract of filter paper on which virgin female moths

had rested for several days (see below). The extract was about a year old when used and had been kept in a stoppered vial in a refrigerator. In the 2 experiments, 67 and 76 male moths respectively were exposed for 15-minute periods in the chambers to a small piece of filter paper on which some of the extract had been rubbed. During the test periods, 27 (40 per cent) and 32 (42 per cent) of the moths were attracted to the extract.

"The chemistry of sex scents is virtually unknown." (Dethier 1947). Probably the most extensively studied insect sex scent, from a chemical standpoint, has been that of the gypsy moth (Haller *et al.* 1944) yet its chemical structure is still unknown, although it is now possible to obtain the active constituent[1] of the gypsy moth attractant (Annand 1949). A number of workers have attempted to isolate the attractive substance from various species of female moths (*e.g.* Barth 1937b; Kettlewell 1946; Flaschentrager & Amin 1950). One of the major difficulties is the small amount of material usually available for analysis (Dethier 1947).

It has been possible to isolate a crude extract from females of *Tineola* which is active for males of the species. When isolated virgin females were kept in mason jars on sheets of filter paper[2], the sex attractant was found to be imparted to the paper. The paper was then extracted with petroleum ether in a soxhlet extractor at 60° C. for 2 hours. The solution was then filtered and the filtrate concentrated over a water bath at 70° C. The attractant isolated in this manner and kept at a low temperature for more than a year was found to be still attractive to males. The female attractant also has been extracted from combed, unspun wool ("Wool Top," Arlington Mills) which had been dusted with Brewer's Yeast and on which virgin females had rested for several days. That some female moth scents may be imparted to the surface on which the females have rested has been reported in the literature (*e.g.*, Green 1899; Antram 1908).

In testing for activity of an extract, small strips of filter paper were dipped in the test solutions, the solvent was then allowed to evaporate and the paper was introduced into a 1000 ml. beaker or large moist chamber containing male moths. The behavior of the moths toward the paper was then observed. Care was taken to introduce the test material only after most of the males had become quiescent. As a control, a strip of filter paper which had been dipped in pure solvent only was first placed in the beaker; male moths were not attracted to filter paper which had been dipped in pure petroleum ether. If an extract showed activity, the males were activated quickly (gave a courting response) and were attracted to the material being tested.

The attractant may also be extracted from the entire bodies of virgin females (extracts made of non-virgin females failed to stimulate males). In one experiment 1000 females were extracted with petroleum ether; successive dilutions (with ether) of the crude extract (a thick yellow oil) were tested for activity against male moths, and a dilution as low as 1:500,000 was capable of inducing the males to court. Considering the fact that the crude extract undoubtedly was mostly impurities, the males undoubtedly respond to concentrations much lower than that indicated by the above figure. Extracting paper on which females have rested may possibly be the better method for isolating the attractant because the same females may be used for several days during which they continue to produce the attractant. This method has been used successfully for isolating, in crude form, the sex attractant from females of *Periplaneta americana* (L.) (Roth & Willis 1952).

Though moth sex attractants are usually specific for the species, it is known that the female of one species may attract the males of another species. This is true both in the laboratory (Woodroffe 1951; Dickins 1936; Barth 1937b) and the field (Sutton 1922; Ford 1926). Kettlewell (1946) has suggested that in some cases the scents of different genera and species of Lepidoptera may be identical. Through the kindness of Mr. J. M. Corliss, in charge of the Division of Gypsy and Brown-tail Moth Control, U.S.D.A., some gypsy moth sex attractant (dissolved in benzol) was obtained. Males of *Tineola biselliella* were exposed to the material, but the results were negative; the clothes moths showed no sexual activity when exposed to the gypsy moth attractant. The gypsy moth sex attractant is spe-

[1] Gyptol.
[2] Shark skin.

cific (Burgess 1950) and according to Corliss (1950) " . . . the number of other species caught in the traps is very small."

DISCUSSION.—The present observations and experiments have shown that like many other Lepidoptera the female of *Tineola biselliella* elaborates a scent which both activates and attracts the male of the species. Compared to some of the forest-inhabiting moths the distance over which the clothes moth attractant is effective is very short. However, from a consideration of the breeding habits of the clothes moth (in relatively confined places in homes and warehouses) it would not be necessary for the male to fly long distances to find a female. Also the courting behavior of the male, his rapid walking about fluttering his wings, would tend to increase his chances of coming within range of the female; this was shown in the experiments using the large moist chambers. The use of a sex-attractant for trapping males of the clothes moth might be valuable for purposes of determining infestations.

Norris (1933) stated that the scent of the female moth *Plodia* is the only stimulus required to excite the male and that males never become excited in the presence of females which are not calling. As noted by Titschack (1922) and the present work this is not the case in *Tineola*. The male clothes moth shows periods of sexual activity which may occur in the absence of the female indicating that the periodicity of male sex behavior is not necessarily dependent on the elaboration of a female scent. The males of the silkworm moth *Bombyx mori* also show spontaneous sex activity in the absence of the female (Chen & Young 1943). It is not too common to see males of *Tineola* courting when they are kept individually in separate dishes, but the fact that they do indicates that internal factors alone may induce males to become sexually active. When many males are kept in the same chamber, isolated from females, large numbers of them may show sexual activity and these active males will attempt to copulate with other males which are quiescent. Since males do vibrate their wings in the absence of the female the question may be raised as to whether or not this response should be considered "courting" behavior in the strict sense. Titschack (1922) considers the vibrating of the male's wings to be either a sign of "excitement" or a method of disseminating male odor, or both. The males of *Habrobracon* may also show mating reactions (*i.e.*, "wing flipping") when in the presence of males only, and Grosch (1948) considers these to be "nonspecific" mating reactions to distinguish them from reactions evoked by female scent. These reactions Grosch explains as being expressions of male excitability no more significant than the running or flying of agitated wasps, or may be due to stimuli to which there is ordinarily no response (*e.g.*, male odor?) which might evoke a mating reaction if males lack discrimination because of a lowered threshold of sensitivity. These explanations could be applicable to the behavior of male clothes moths. However, since the male of *Tineola* almost invariably attempts to copulate with a female when he comes in contact with one during the period when he is walking about fluttering his wings, this latter behavior has been considered by the writers to be a courting response, even when elicited in the absence of a female. The courting response could be interpreted as stereotyped movements accompanying "searching" behavior (*i.e.*, during the search for a mate; Tinbergen 1942, 59–62).

In the light of the modern concept of instinctive behavior (see Tinbergen 1942; Thorpe 1948) the mating behavior of the male *Tineola* may be explained as follows: Shortly after emergence the male builds up a "kind of specific tension in the central nervous system" which is released (evidenced by the courting response) when the male is stimulated by the female odor. However, if the releaser (i.e., female odor) is not present (in the absence of a female), the reaction specific energy is "dammed up." This causes a lowering of the threshold of stimuli effective in releasing the courting response, and if the male is isolated from females long enough, the tension may reach a level at which the male performs the courting response without the presence of any apparent external stimulus. This last behavior is referred to as "vacuum activity" and may explain the courting behavior of isolated males. The releaser for the clasping response (Fig. 1, arrow) apparently is simply a mechanical one (*i.e.*, contact with another moth; cf. Kellogg 1907) and explains why

a courting male will attempt to copulate with a quiescent male, when he comes in contact with one.

SUMMARY.—Females of the webbing clothes moth elaborate a scent from the abdomen, which activates (*i.e.*, induces courtship behavior) and attracts the males of the species. The distance over which the scent from a single isolated female abdomen is effective in attracting the males is about 1.5 cm.; this distance can be increased by increasing the number of female abdomens used as a source of the attractant. When virgin females are kept on sheets of filter paper, the sex-attractant is imparted to the paper and can be extracted with petroleum ether. The crude extract may be kept for as long as a year at refrigerator temperatures and still retain its ability to activate and attract male moths.

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Microbioassay of Insecticides, with Special Reference to Aldrin and Dieldrin[1]

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The discovery of newer and more toxic insecticides during recent years increases the importance and necessity of determining minute quantities of insecticidal residues on plants and in animal tissues. Since chemical methods of analysis may not be developed along with the application of new insecticides or may not be sensitive enough for analyzing microquantities of toxicants, microbioassay methods which have been used for determining insecticidal residues can be easily modified and applied to the bioassay of residues containing newer insecticides. This may be the reason that the microbioassay method has been considered as an alternative means of studying insecticidal residues.

During the last few years various bioassay methods have been published by research workers in the determination of microquantities of insecticidal residues. Because the principles of applying bioassay methods to microquantitative assays had not been well developed, the degree of reliability in results and the success of determining microquantities of toxicants in different materials varied greatly. In this paper an attempt is made to reveal certain important principles used in the microbioassay of toxicants, to describe general procedures of carrying out such tests, to compare different methods for evaluating results and to devise a method of estimating the sensitivity of each determination.

Laug (1946, 1948) has made a pioneer study of the distribution of DDT and gamma isomer of benzene hexachloride (γBHC) in animal tissues by means of bioassay. His method was based upon the mortality of the house fly, *Musca domestica* L., to the deposit of a given tissue extract as compared with a set of standards made from known amounts of the same insecticide. About 20 mg. of corn oil were added to each flask to prevent losses of γ-BHC in the standards during and subsequent to the evaporation of the ether solution. The same principle was followed by Dahm & Pankaskie (1949) in the bioassay of aldrin. Instead of exposing house flies continuously in the treated vessels, Furman & Hoskins (1948) and Hoskins & Messenger (1950) exposed them for 30 minutes in small vials. For the bioassay of parathion in plant materials, Nolan & Wilcoxon (1950) devised a method for testing suspensions of extracts in water against *Aëdes aegypti* larvae and compared the results with standards made from comparable blank extracts. Hartzell & Storrs (1950) described a similar method for the bioassay of various insecticides in processed foods. Fleming *et al.* (1951) used *Macrocentrus ancylivorus* Roh. for the bioassay of chlordane and DDT in soil. When both toxicants were present, chlordane was first assayed and then removed by wetting and drying the filter papers in petri dishes before assaying DDT. Bushland (1951) tested the insecticidal residues in animal products by using mosquito larvae, *A. aegypti* (L.). By confining house flies near the residue on a petri dish for 1 hour, Stansberry & Dahm (1951) determined by a bioassay method the residue of aldrin, chlordane, parathion, and toxaphene in alfalfa.

PRINCIPLE OF MICROBIOASSAY.—Arbitrary procedures are generally given in the literature for the bioassay of insecticidal residues. Few experiments and discussions have emphasized those principles of microbioassay which are essential for a successful solution of the problem under various conditions. Before describing the procedures of microbioassay and methods of interpreting results, it is well first to discuss the general principle of microbioassay of insecticides.

In this paper the insecticidal residues are evaluated with a residue method, by which adult house flies are continuously exposed to a "dry" film of deposit. Because of the presence of various compounds in plants and animals, the deposit from an extract may be a liquid, semisolid, or solid film which may vary in its

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Paid Paper.

effect on the toxicity of the insecticide to test insects. The extracted materials which are usually unknown in composition and highly sorptive may weigh as much as 1,000 to 100,000 times more than the actual amount of a toxicant in the extract. Such a high ratio of extracted materials to toxicant may cause a great deal of difficulty in the determination of the toxicant by chemical, physicochemical, or biological methods. In addition to a purely physical action in diluting the active toxicant in the deposit, the toxicant may be sorbed by extracted substances so that its effect on insects may be masked. Twenty milligrams of corn oil, lard, and wax in each jar decrease the toxicity of dieldrin to about two-thirds, one-third, and one-fourth respectively, and 2.5 and 20 mg. of wax in a jar can reduce the toxicity to house flies of 3 micrograms of dieldrin from 84 per cent to 41 and 17 per cent mortality respectively. The above facts illustrate the effect of nontoxic residues on the toxicity of an insecticide. Under actual conditions the variation of the quality and quantity of total residues may be much greater. The presence of naturally toxic materials in plant or animal extracts makes the problem even more complex.

It has been demonstrated by Sun (1950) that many factors which change the LD 50 values of insecticides tested on house flies do not appreciably affect their toxicity indexes. The consistency of the toxicity index under different conditions appears to arise from the fact that the change in the LD 50 of a test sample is accompanied by a proportional change in the LD 50 of the standard insecticde. Sun also pointed out that, theoretically, by using a standard having the same composition as the test sample, the results should be the same when tested with any species of insect, by any method of applying insecticides and under any testing conditions. On the basis of the above theory and supporting facts, it appears that, by extending the findings on toxicity index to different mortality levels for microbioassay, the mortality of insects should be the same if two extracts contain the same quantity of the same toxicant as well as the same amount of the same extracted materials. Therefore, standards should be made by adding suitable amounts of the same toxicant to a blank extract prepared from an untreated check in the same way as the treated samples. If the extract from a treated sample gives the same mortality as one of the standards, the amount of insecticide in the treated sample should be the same as that in the standard. On a comparative basis, the extracted substances other than toxicants should not change the results, but decrease the sensitivity. For example, the

Table 1.—Results of microbioassay experiment designed for analyzing the presence or absence of insecticidal residue by the ranking method for grouped data.

Sample	Extraction Ratio, G./Ml.	Vol. of Extract per Jar, Ml.	Total Residue in Extract Mg./Ml.	Deposit in Each Jar: Total Residue, Mg.	Deposit in Each Jar: Aldrin[1] Added, Microgram	Per Cent Mortality 24 Hr.	Rank
Standard, made with an untreated alfalfa extract	2.4	0.7	6.6	4.6	2	3	1
						3	2
		0.7	6.6	4.6	3	25	2
						19	1
		0.7	6.6	4.6	5	56	1
						58	2
						Total	9
Treated alfalfa extract	2.0	1.2	3.8	4.6	2	31	3
						34	4
		1.2	3.8	4.6	3	55	3
						63	4
		1.2	3.8	4.6	5	86	3
						89	4
						Total	21

[1] m.p. 103–104° C.

aldrin content of a prepared rat diet containing 5.0 p.p.m. of aldrin is determined by the microbioassay method. Even when the average weight of total residues in the extracts is as high as 120 mg. per ml. and the LD 50 of aldrin in the rat-diet extract is about 6 times higher than aldrin alone, by adjusting to the same amount of total residues in each jar for both standard and test samples, the amount of aldrin determined by the microbioassay method is 4.7, 5.1, 5.3, and 5.2 p.p.m. with an average value of 5.1 p.p.m.

PRECAUTIONS FOR OBTAINING AND PREPARING SAMPLES FOR MICROBIOASSAY.—Extreme caution is needed to successfully carry out microbioassay tests and the precautions observed in the following are essential. One of the most serious troubles in most laboratories will be that of accidental contamination. All possibility of error from this source must be avoided or the value of the experiment is doomed at the outset.

Plants which are assigned as untreated check in the field should be taken before treatment or protected from the drifting of insecticides during treatment. It was found that one untreated alfalfa sample obtained from an agricultural experiment station contained as high as several p.p.m. of a toxicant when it was collected immediately after treatment. This finding demonstrates that drifting during treatment made the alfalfa in the untreated check plot valueless as the blank from the extract of which standards are prepared for microbioassay. Therefore, in order to obtain more comparable results, large field plots are preferable to small ones; sprays are preferable to dusts; and calm weather is preferable to windy weather.

In field experiments the deposit of insecticides on plants is less uniform than that obtained from laboratory tests. In eliminating field variations, proper sampling methods should be used in obtaining sufficient, representative samples for residue analysis. After thorough mixing, large duplicate samples should be extracted immediately, in order to avoid possible losses due to volatilization or decomposition. Some of the samples which had been received for insecticidal residue determination were not large enough to provide for duplicate runs. To cover the extra needs for evaluating the toxicant in samples and for recovery tests, the amount of untreated samples should be at least 2 to 3 times treated ones. The exact weight of samples required for microbioassay depends upon the desired sensitivity of final results as well as the amount of insecticidal residue. Samples which cannot be extracted after sampling should be stored properly in tight containers, preferably glass jars.

Since microquantities of toxicants in animals and plants may be partly lost or destroyed in the protracted processes of handling, the method of preparing solutions for microbioassay should be as simple as possible. For example, in the determination of insecticidal residues on fruits, simple washings with or without concentrating the extracts can be applied successfully for the microbioassay of nonsystemic insecticides. However, under certain circumstances materials have to be subjected to special treatments in order to get satisfactory solutions for microbioassay. To test the efficiency of extraction, concentration and other processes, a known amount of toxicant should be added to an untreated sample before extraction. A high percentage of recovery of the added toxicant is the criterion of a satisfactory extraction procedure. Generally 25 to 200 g. of a sample may be taken as a convenient size for extraction.

MICROBIOASSAY PROCEDURES.—Since an extract may contain varying amounts of dissolved substances which affect, in various degrees, the toxicity of an insecticide in it, the amount of total residues should be first determined. If the final volume of an extract is reduced to 25 ml., 1 ml. of the extract may be measured for determining the total residues or for test. However, if the final volume of an extract is more than 25 ml. the volume of extract used for the above purposes may be increased by proportion. To increase the sensitivity of results, larger volumes of an extract may be used for tests.

For inexperienced workers a preliminary test is necessary for estimating the amount of a toxicant in treated extracts. However, for extracts containing higher insecticidal residues a preliminary test should be made even by experienced workers, before carrying out actual determinations. With a proper selection of the following four methods more accurate results can be obtained.

After bioassaying aldrin and dieldrin residues in a large number of extracts, it was found that methods 1 and 2 have been used for samples, such as alfalfa, cherries, chicken liver and fat, corn, cotton seed oil, dates, human brain, kidney, liver, and lung, lemons, lima beans, oranges, peaches, peanuts, potatoes, radishes, rye, sweet potatoes, turnips, and wheat; method 3 applied to samples, such as olive oil and soil; and method 4 applied to samples, such as fats obtained from beef, calf and dog which were fed with heavy doses of toxicants for experimental purposes.

METHOD 1.—*Ranking method for analyzing the presence or absence of insecticidal residue.*—From the experience of determining certain types of extracts or from the results of preliminary tests, the presence or absence of a toxicant in a sample can be determined by the following method, and analyzed statistically by the ranking method[3] for grouped data (Wilcoxon 1946).

If all extracts of the same series of experiments contain the same amount of total residue per unit volume, same volume of each extract is measured into a wide-mouth pint jar. If the extract of either a sample or the standard does not contain the same amount of total residue, the volume pipetted into each jar should be so adjusted that the total residue should be the same in all cases. If the extract does not contain enough toxicant to give a moderate kill of house flies, suitable amounts of the same toxicant, as illustrated in table 1, are added at three levels. Standards are made from a comparable blank extract by adding the same amounts of the same toxicant corresponding to the treated samples. Then by rotating the jar, the solutions are thoroughly mixed and uniformly distributed over the bottom until the solvent evaporates to dryness. For both standards and samples, two replicates are made for each of three levels of a toxicant. About 15 minutes after the deposit is dry, 100 one-day old house flies which have been carefully mixed and sampled are transferred into each jar and fed with milk absorbed on a large piece of cotton which is placed on the side of the jar. Then each jar is covered with a piece of new cheese cloth and kept on its side at 80° F.

The mortality of flies should be counted only when it is within a proper range (20 to 80 per cent) of comparison. Both moribund and dead flies are counted as dead. The time of observing mortality may vary from 17 to 24 hours (or more) from one series of samples to another. If the mortality of flies is too low for one of the samples it should not be counted until the mortality of both samples and the standard of the same series is within a better range of comparison. This is the reason why the mortality of the standard in table 1 is lower than usual. After counting, all jars are soaked in hot water, washed thoroughly with cleanser, rinsed with water, dried and heated over night at 90° C. or higher in order to eliminate the last trace of toxicant. If waxy extracts are deposited in jars, it is necessary to rinse each jar with benzene followed by the above cleaning process.

An alfalfa sample containing an unusually high aldrin residue may be used as an example for this method (Table 1) and also for methods 2 and 3. Because of differences in the quantity of residues in different extracts, it is necessary to adjust the volume of extracts deposited in each jar so that the total residue (4.6 mg.) per jar is the same for both standard and treated samples. The toxicity of deposits made from a treated extract and containing the same amounts of added aldrin as the corresponding standard is significantly greater than the toxicity of the standard by odds greater than 100 to 1, when analyzed by the ranking method for grouped data (Wilcoxon 1946). Therefore, the treated sample contains a small amount of aldrin. The next step is to calculate the amount of aldrin in the treated extract.

METHOD 2.—*LD 50 method for calculating traces of insecticidal residue.*—The result obtained in method 1 indicates that the alfalfa sample contains a small but significant amount of aldrin. By the knowledge of previous data (Tables 1 and 2), the aldrin residue on alfalfa can be calculated by either the LD 50 method or the interpolation method. For traces of insecticides in the residue, the LD 50 method which gives less variation in results as compared with the interpolation method (Method 3) is described as follows:

[3] Several ranking methods are illustrated in the booklet: "F. Wilcoxon. Some rapid approximate statistical procedures." American Cyanamid Co., Stamford, Connecticut.

Table 2.—Results of microbioassay experiment designed for samples containing traces of a toxicant and calculated by the interpolation and LD 50 methods.

Sample	Deposit in Each Jar: Total Residue Mg.	Deposit in Each Jar: Aldrin Added, Microgram	Average Per Cent Mortality 24 Hr.	Aldrin Found by Interpolation Method, Microgram per Jar	Aldrin Found by LD 50 Method: LD 50, Microgram	Aldrin Found by LD 50 Method: Microgram per Jar
Standard, made with	4.6	2	3	—	4.45	
untreated alfafa ex-	4.6	3	22	—		
tract	4.6	5	57	—		
Treated alfalfa extract	4.6	2	32.5	3.65−2=1.65	2.74	
	4.6	3	59	4.9 −3=1.9		
	4.6	5	87.5	7.2 −5=2.2		
				Av. 1.9		4.45−2.74 =1.7

From the results obtained by method 1, a standard dosage-mortality curve is plotted on log-probit scales, and a similar curve is plotted for the treated sample. The difference in LD 50 values between the standard (4.45 micrograms) and the treated sample (2.74 micrograms) is the amount of aldrin (1.7 micrograms) in 1.2 ml. extract (Table 2). The result is positive when the LD 50 of the standard is greater than that of a sample and vice versa. However, the slope of the dosage-mortality curve for a treated sample will be increasingly flat when the amount of a toxicant in the sample is higher and higher. Therefore, the LD 50 method is not too accurate for comparing against the standard when the amount of insecticidal residue is high, unless the dosage-mortality curve is plotted at an equal dosage distance from the standard curve at all levels of mortality.

Method 3.—*Interpolation method for evaluating small amounts of insecticidal residue.*—Since the alfalfa sample contains more than a trace of aldrin, the results can also be analyzed by the interpolation method. With the same standard curve in method 2, the mortality of insects produced by each deposit is first located in the standard curve. From that point a perpendicular line is projected down to the abscissa where the number of micrograms of aldrin is found. Subtracting the amount of added aldrin from the value obtained by the interpolation method, corresponding values of aldrin are obtained for each extract at each level (Table 2). The average value of three results for treated alfalfa is 1.9 micrograms of aldrin in 1.2 ml. extract as compared with 1.7 micrograms obtained by the LD 50 method. The validity of this method of evaluation will be discussed again in the section on sensitivity of microbioassay (Table 5). A change of slope in the interpolation of a dosage-mortality curve may greatly change the results at low and high mortalities. Better results can be obtained by this method when the mortality range is near 50 per cent which is the center of rotation of most curves having points equally distributed above and below the 50 per cent point. For practical applications of the interpolation method, a concentration of toxicant producing 40

Table 3.—Results of microbioassay experiment designed for samples containing small amounts of toxicant and calculated by the interpolation method.

Sample	Deposit in Each Jar: Total Residue Mg.	Deposit in Each Jar: Aldrin Added, Microgram	No. of Replicates	Average Per Cent Mortality 22 Hr.	Aldrin Found by Interpolation Method Microgram per Jar
Standard, made with an	4.6	3	2	43	
untreated alfalfa extract	4.6	4	2	53	
	4.6	5	2	59	
	4.6	6	2	69	
Treated alfalfa extract	4.6	3	6	61	4.9−3=1.9

to 60 per cent mortality may be considered as a good range for more accurate comparison.

Since the aldrin residue in this sample is unusually high, a specially designed method is used for determining the insecticidal residue with the interpolation method. By the knowledge of previous results, one concentration is selected and will produce a mortality of near 50 per cent. The experiment was carried out in the same way as that in method 1, with the adjustment of volume to produce the same amount of total residues for both the standard and the treated sample (Table 3). The standard dosage-mortality curve is plotted. By the interpolation method the actual amount of aldrin per jar is 4.9−3.0 or 1.9 micrograms of aldrin which is very close to the results obtained in table 2, i.e. 1.9 and 1.7 micrograms of aldrin in 1.2 ml. extract. The following equation is used to calculate the insecticidal residue in terms of p.p.m. (parts per million) in the original sample. Since 50 g. of alfalfa were extracted, treated, and concentrated to 25 ml., the extraction ratio is 2.

$$\text{Toxicant in treated sample} = \frac{\text{Toxicant found (microgram per jar)}}{\text{Extract. ratio (g/ml.)} \times \text{vol. of extract per jar (ml.)}}$$

$$\text{or aldrin residue in alfalfa} = \frac{1.9}{2.0 \times 1.2} = 0.79 \text{ p.p.m.}$$

METHOD 4.—*Interpolation method for determining larger amounts of insecticidal residue.*—When an extract contains a relatively larger amount of a toxicant, a preliminary test is necessary to determine the range of toxicity of the extract. Either smaller volumes of the extract or more dilute extract should be used for making deposits in jars in order to find a proper concentration for the interpolation method of comparison. By reducing the volume used in each deposit, the amount of total residue is reduced at the same time. Since both the standard and the treated extract should have the same amount of the same residue in all jars, the amount of residue as well as the toxicant in it should be adjusted at the same time by calculation. In table 4, the total residues of extracts from waxed cards are low and different. Since it is not easy to weigh accurately such low residues on an ordinary analytical balance, the percentage of variation in total residue is great. In addition, if a very volatile toxicant is present in the extract, it is necessary to add more residue in each jar to hold back the toxicant by sorption. Although dieldrin, a residual toxicant, is actually present in the waxed-card extract, the following example illustrates the method of adjusting residue by adding another substance, such as corn oil in acetone solution.

Tests on the extract of waxed cards are carried out in a similar way as described in method 3. The total weight of residue is adjusted with different volumes of extracts and the addition of 1 ml. of 1 per cent corn oil. It is found that 4.8 micrograms of dieldrin are present in 0.2 ml. extract which is equivalent to 24 micrograms of dieldrin per milliliter (Table 4). In another determination the amount of dieldrin is 21 micrograms per milliliter. Since this is a laboratory deposit of dieldrin sent from an agricultural experiment station, further calculation is not necessary.

SENSITIVITY OF MICROBIOASSAY.—Sensitivity of microbioassay methods varies greatly with the toxicity of insecticides to test insects. The detectable amount of several toxicants is quoted according to authors' data or conclusion. Laug (1946) found that 2.5 p.p.m. of DDT can be determined in animal tissues and excreta. He (1948) also reported that as low as 0.2 p.p.m. of γ-BHC can be determined in tissues, but in fat, concentrations of γ-BHC lower than 10 p.p.m. were considered outside the zone of reliability. Carter *et al.* (1949) stated that with the synthetic cream which was made with skim milk and butter DDT concentrations of 50 p.p.m. or less could not be definitely detected on the basis of fly mortalities. Dahm & Pankaskie (1949) reported that house flies can detect as low as one microgram of aldrin per jar. Nolan & Wilcoxon (1950) can determine about 0.02 p.p.m. of parathion by using mosquito larvae. Hartzell & Storrs (1950) observed that the *Aëdes aegypti* larvae can detect approximately 0.03 p.p.m. of dieldrin and lindane, 0.06 p.p.m. of aldrin and heptachlor and 0.5 p.p.m. of chlordane in processed foods. With *A. aegypti* larvae Bushland (1951) can determine 0.5 p.p.m. of lindane in milk.

Sensitivity is defined here as the mini-

mum amount of a toxicant which can be significantly detected in extracts and calculated as p.p.m. in the original sample. From experimental results sensitivity of a microbioassay method varies with the toxicity of insecticides, the susceptibility of the test insects to insecticides, the amount of material extracted, the final volume of the extract, the volume of an extract in each jar, the quality and quantity of interfering substances in the extract, the contact time between insects and toxic residues, and probably other factors. When all factors are fixed, the sensitivity of a particular method can be determined. If an extract contains a sublethal amount of insecticide which does not kill the test insects, it is not proper to conclude that no insecticidal residue is present in that sample. It has been found that by adding a suitable amount of the same insecticide to such samples the mortality of insects can be increased to a favorably comparable range and small, sublethal quantities of an insecticide can be detected and calculated from the results with fairly good accuracy (Tables 2, 3, and 5). With the above technique one can detect as little as 0.4 microgram of aldrin or dieldrin in each jar containing a few milligrams of total residue or about one seventh of the LD 50 of a toxicant or about 0.1 p.p.m. of aldrin or dieldrin in a 100 g. sample.

Theoretically, the amount of insecticide added to a sample or an extract should produce the same toxicity as an equal amount of the same insecticide present in the original sample, provided the insecticide is present in the same physical state and other test conditions are equal. It should be true that in an extract no difference in toxicity should be found between a given amount of an insecticide in the original extract and the same amount of the same insecticide added later, since the physical state is the same whether the insecticide is present in the original sample or added later. However, in milk, the insecticide added later may be present as a colloidal suspension of various particle sizes or may gradually go into solution in the same physical state as the original insecticide in the sample. Differences in physical state may cause differences in the toxicity of an insecticide to insects. If this method gives the same results as the direct determination for the bioassay of a toxicant in milk samples, it should be applicable to extracts with the same accuracy. The following example proves the validity of the above principle in actual practice and illustrates the method of adding known amounts of the same toxicant to milk samples in order to determine smaller amounts of dieldrin which may escape detection.

When the amount of dieldrin was determined in milk samples obtained from cows heavily treated with dieldrin by an agricultural experiment station, it was found that at low levels of dieldrin in milk it was necessary to add a small amount of dieldrin to treated milk samples to dertermine the presence of dieldrin in milk. In table 5 some of those milk samples were determined by the feeding method with and without adding 1 to 2 p.p.m. of dieldrin to the samples. The added amounts of dieldrin were deducted later in the calculation to give the amount of dieldrin in the samples. The results obtained by the above two methods are 1.5, 0.8, 1.7, and 1.4 p.p.m. by direct determination and 1.8, 0.6, 1.9, and 1.7 p.p.m. for respective samples by adding a known amount of dieldrin to each sample. The differences are within the range of experimental errors (Table 5). The method of determining insecticides in milk by the feeding method will be published in another paper.

It is a familiar fact that the sampling error and other experimental errors may greatly affect the true results in field experiments. This is even more true for the microbioassay of insecticidal residues. Samples which do not contain any trace of insecticides may not give a zero value in actual determinations. Therefore, accompanying microbioassay data the sensitivity of a method should be mentioned in order to indicate the significance of each determination. On the basis of several hundred determinations of insecticidal residues from various materials, the following equation was devised for an approximate evaluation on the sensitivity of the above residue method of microbioassay.

$$\text{Sensitivity} = \pm\frac{D\times F}{R\times V}$$

Where D is the LD 50 of a standard curve expressed as micrograms of an in-

Table 4.—**Results of microbioassay experiment designed for samples containing relatively larger amounts of toxicant and calculated by the interpolation method.**

Sample	Vol. of Extract per Jar Ml.	Residue in Extract Mg./Ml.	Corn Oil Added Mg.	Deposit in Each Jar: Total Residue Mg.	Deposit in Each Jar: Dieldrin[1] Added, Microgram	No. of Replicates	Average Per Cent Mortality 41 Hr.	Dieldrin Found Microgram per Jar
Standard, made with an untreated waxed-card extract	0.8	0.5	10	10.4	3	2	32	
	0.8	0.5	10	10.4	4	2	35	
	0.8	0.5	10	10.4	6	2	54	
	0.8	0.5	10	10.4	8	2	78	
Treated waxed-card extract	2.2	0.2	10	10.4	0	6	48	4.8

[1] m.p. 175–176° C.

secticide per jar; F is a factor of accuracy which may very from one-fifth to one-tenth depending upon the number of replicates and the degree of variation of results; R is the extraction ratio expressed as the number of grams of a sample per milliliter of the final extract; and V is the volume of a treated extract in milliliters added into each jar. The final result is expressed in p.p.m. of the toxicant in a sample.

For example, if the LD 50 of the standard is 5.0 micrograms per jar, the extract contains 5.0 grams of sample per milliliter of extract, the volume of extract in each jar is 1 ml., and the replicated data are accurate enough to use one-tenth for F, then the sensitivity is calculated as follows:

$$\text{Sensitivity} = \pm\frac{5.0\times 1/10}{5.0\times 1} = \pm 0.1 \text{ p.p.m.}$$

If greater variations are found in the replicates, one-fifth may be used for F to calculate the sensitivity. Therefore, the sensitivity of the above sample may vary from ± 0.1 to ± 0.2 p.p.m. depending upon the results. To test the degree of agreement between the sensitivity calculated by equation 1 and the results analyzed by the ranking method, the sensitivity of 100 determinations, half of which give non-significant amounts of residue, has been calculated and tabulated in table 6. When samples do not show significant amounts of toxicants at 0.05 level, only those results which are greater than the value calculated by equation 1 with $F=$ one-fifth do not agree with results obtained by the ranking method. On the other hand, when samples show significant amounts of toxicants at 0.05 level, those results which are less than the value calculated by equation 1 with $F=$ one-tenth do not agree with results obtained by the ranking method. In 100 determinations, the sensitivity of 97 per cent of results calculated by equation 1 agrees with the ranking method and only 3 per cent of cases are out of range. Two of these three cases would agree with the ranking method if 0.02 instead of 0.05 level is used to indicate the significance.

In practical applications, equation 1 may be used for average cases to obtain approximate values of the sensitivity of results or to calculate the size of a sample requiring a desired sensitivity. The sensitivity of some actual determinations has

Table 5.—**Comparison of results of microbioassay of dieldrin in milk with or without adding a known amount of the same toxicant; results are calculated by the interpolation method.**

Dieldrin in Milk Samples p.p.m.	Dieldrin Found, by Adding a Known Amount, p.p.m.: Dieldrin Determined (1)	Dieldrin Added (2)	Dieldrin in Milk (1)–(2)	Dieldrin Found by Direct Determination, p.p.m.	Differences in Results p.p.m.
Unknown	2.8	1	1.8	1.5	+0.3
Unknown	1.6	1	0.6	0.8	−0.2
<2.0[1]	3.9	2	1.9	1.7	+0.2
<2.0[1]	3.7	2	1.7	1.4	+0.3

[1] A mixture of several milk samples containing less than 2.0 p.p.m. of dieldrin by calculation.

Table 6.—Degree of agreement between the sensitivity of microbioassay tests calculated by equation 1 and the significance of results analyzed by ranking method for grouped data.

Results Analyzed by Ranking Method	Total No. of Cases Analyzed	Value of F in Equation 1	No. of Results Agreed with Sensitivity Calculated with Different Values of F	Percentage of Cases Calculated by Equa. 1	
				Agreed with Ranking Method	Not Agreed with Ranking Method
Not significant at 0.05 level	50	When F<1/10	26	52	
		When F=1/10 to 1/5	23	46	
		When F>1/5	1		2
Significant at 0.05 level	50	When F>1/5	30	60	
		When F=1/10 to 1/5	18	36	
		When F<1/10	2		4
Total	100			97	3

been increased to 0.02 p.p.m. by increasing the size of samples. However, a proper weight of sample should be selected for the convenience of extraction. For any particular case requiring more accuracy in determining the significant value, the results should be analyzed individually.

INTERFERENCES IN MICROBIOASSAY.—Since the accuracy and success of microbioassay methods depend upon the sensitive action of the toxicant to insects, interferences which are caused by either extracted materials or contamination may upset the final results. If the test insect is more sensitive to toxicants, it is more susceptible to the contamination as well as the naturally toxic substances in plants or animals.

It has been a common observation that extracted materials from plant or animal tissues often decrease the toxicity of insecticides in the extracts (Laug 1948; Hoskins & Messenger 1950; Hartzell & Storrs 1950; Bushland 1951 and Fleming *et al.* 1951). However, it has also been reported that extracts of liver, kidney and brain (Laug 1948) from control animals are toxic to house flies; that high concentrations of extracts from processed food appear to kill mosquito larvae (Hartzell & Storrs 1950); and that unripe, unsprayed peaches are toxic to mosquito larvae at dilutions of 1 to 7.5 and 1 to 15 (Hartzell 1950).

Tests of more than 30 different plant and animal extracts reveal that only orange oil is toxic to house flies. However, such toxic materials in orange oil can be removed by volatilization. It has been mentioned that the interference of nontoxic substances extracted from plants or animals can be corrected by using the same quantity and quality of a blank extract to make standards. Low toxicity due to plant or animal extracts can be handled in the same way. However, if blank extracts are highly toxic, it is obviously necessary to remove the unknown toxic substances (not insecticides) before reliable results can be obtained.

Contamination has been the worst enemy in the microbioassay of insecticidal residues. Some of the early blank extracts were found to be highly toxic, but it was proved later that the toxicity was due to contamination. Such contamination can be introduced in the field, in the handling and processing of materials, in extraction, and in the processes of microbioassay. If contamination is overlooked and not eliminated, the results are likely to be confusing and misleading. Hartzell & Storrs (1950) described a rather elaborate method of cleaning the glassware for mosquito larvae tests. From their procedures of cleaning glassware, one may realize the seriousness of contamination. A relatively simple method for cleaning glassware was described in method 1 and has been proved to be very successful.

DISCUSSION.—The discovery of new insecticides is not uncommon these days. However, an accurate chemical method of analyzing a few micrograms of a new toxicant, especially in the presence of a large amount of interfering materials, is usually not available within a short period of time for practical applications on residue problems. During such a period of time microbioassay is the ideal method to deal with the residual problems.

Compared with chemical or physico-

chemical methods in the determination of microquantities of toxicants, microbioassay methods are less affected by interfering substances in many plant or animal extracts. Of more than 30 varieties of extracts tested with microbioassay methods, only orange oil gives a significant toxic interference to the microbioassay method. However, such interference has been successfully eliminated. Orange oil also contains substances which interfere with the chemical and physico-chemical methods.

As has already been mentioned, the sensitivity of microbioassay methods depends upon a number of factors, the most important of which is the toxicity of insecticides to test insects. If an insecticide is highly toxic to most insects, it is easier to select a proper species of insect for the microbioassay method. However, if an insecticide is very toxic to only a few species of insects, the selection of a proper test insect is rather limited. When an insecticide is only slightly or moderately toxic to insects, then the sensitivity of a microbioassay method will be greatly reduced.

It has been a common belief that chemical methods of analysis are specific, while bioassay methods are non-specific. This statement is true only to a certain extent. A few examples will prove that chemical methods of analysis are also not very specific. As we know, the total organic chlorine method has been used by many chemists to determine the insecticidal residues of chlorinated hydrocarbon insecticides. This method is not specific, because organic chlorine from any chlorinated organic insecticide or from natural organic compounds containing chlorine can not be distinguished. The more specific colorimetric method for DDT proposed by Schechter & Haller (1944) will produce an interference color from o,p′-DDT. The colorimetric reaction for the determination of aldrin (Danish & Lidov 1950) can be interfered with by bicyclo-(2.2.1)-5-heptene-2,3-dicarboxylic acid dimethyl ester,[1] and the *N*-octyl imide of bicyclo-(2.2.1)-5-heptene-2,3-dicarboxylic acid.[2] Since a chemical analysis is based upon the reaction of a reagent to a certain structure of a compound, other compounds having the same reactive structure may produce the same or similar reactions at the same time. In the natural materials the composition is rather complex and generally unknown. Interferences are often encountered in the chemical and physico-chemical analyses of microquantities of toxicants in natural products. From experiences with the present microbioassay method, no serious interferences have been encountered. The presence of extracted substances which reduce the toxicity of an insecticide in the deposit can be counter-balanced by using the same quantity of a blank extract in making up the standard. The toxicity from different insecticides cannot be distinguished by microbioassay methods if a mixture of several insecticides are applied. However, in experimental work, only one insecticide is usually applied. Therefore, the interference from other insecticides is not a problem in research work.

Since there are an increasing number of insecticides on the market and the problem of controlling different insects on the same crop is complex, it is necessary to apply mixtures of several insecticides. In addition to the above facts, various insecticidal mixtures are sold by formulators. The determination of insecticidal residues under practical conditions becomes a complicated problem. If chemical methods of analysis are used, one may have to analyze many insecticides on the market in order to find all toxicants present in the residue of unknown history. Each toxicant present in the residue may be so small that it may escape chemical detection. However, the toxicity of a combination of these residues may still impose a hazard to men or animals. Furthermore, there are some insecticides which do not have satisfactory chemical methods of determination. It would seem then that the chemical method may not be in a better position than the bioassay method for handling residue problems of unknown history of treatments. Then an alternative way to handle the complex residual problem may be the determination of a total toxicity by microbioassay methods. As discussed above, results from the microbioassay methods can not tell us what toxicants are present in the residue if the residue is of unknown history or of a mixture of several insecticides. However, it can give us information on the total toxicity of the residue present in plants or animals. If the above idea of determining

[1] *Dimalone.*
[2] *Octacide 264.*

total toxicity is acceptable, one (or more) species of insects may be selected as an arbitrary standard testing animal to evaluate the total toxicity of insecticidal residues. Because of species specificity in toxicological studies, different species of insects or animals may be quite different in their susceptibility to the same toxicant, and their toxicity data may not have direct correlation to higher animals. The same drawback also exists in studying the toxicology of insecticides to small mammals.

SUMMARY.—A microbioassay method for determining insecticidal residues with adult house flies on dried deposits has been developed on the basis of the principle that deposits containing the same amount of the same toxicant and the same quantity and quality of extracted substances should give the same percentage of mortality. Extracts made from more than 30 different materials do not interfere with the determination, but decrease the sensitivity of results.

Several modifications of the method are described for testing extracts and evaluating results for samples containing various amounts of micro-quantities of toxicants: (1) Ranking method for analyzing the presence or absence of insecticidal residue; (2) LD 50 method for calculating traces of insecticidal residue; (3) interpolation method for evaluating small amounts of insecticidal residue; and (4) interpolation method for determining larger amounts of insecticidal residue. Examples are given for each of the above methods. In all cases a comparable blank extract is used to make up standards. Adjustment of the amount of total residue in each jar is necessary if the extracts in the same series do not contain the same weight of total residue per unit volume. Additional residue is added, if an extract contains a small amount of total residue and a more volatile toxicant.

To increase the sensitivity of microbioassay, a known amount of the same toxicant is added to the treated extract which contains a small, but sublethal amount of toxicant. The actual quantity of a toxicant in the residue is obtained by subtracting the added value from the result. By using this method one can determine a residue of as low as 0.4 microgram of aldrin or dieldrin in each jar containing a few milligrams of total residue or about one-seventh of the LD 50 of a standard or about 0.1 p.p.m. of aldrin or dieldrin in a 100 g. sample. The approximate sensitivity of the suggested residue method of microbioassay can be calculated by the following equation and expressed in p.p.m. of the toxicant in a sample.

$$\text{Sensitivity} = \pm\frac{D \times F}{R \times V}$$

Where D is the LD 50 of a standard curve expressed as micrograms of a toxicant per jar; F is a factor of accuracy which may vary from one-fifth to one-tenth depending upon the number of replicates and the accuracy of results; R is the extraction ratio expressed as the number of grams of a sample per milliliter of the final extract; and V is the volume of a treated extract in milliliters added into each jar. In 100 determinations the sensitivity of 97 per cent of results calculated by the above equation agrees with the analysis of the ranking method. The same equation can also be used to calculate the approximate size of a sample requiring a desired sensitivity.

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Ovisorption as the Mechanism Causing Worker Development in Ants

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Polymorphism which is the common occurrence within a species of two or more adult forms of the same sex is characteristic of certain social and nonsocial insects. It is manifested by species in which food utilized at a certain critical period in ontogeny stimulates development along one of two or more inherently possible lines (Schmieder 1939).

In the Hymenoptera the extent or degree of morphological differentiation appears to vary with the stages of development in which differentiation is induced, being much less marked when induced during the larval stages as in the honeybee and the ectoparasite *Melittobea chalybii* than when induced during the primordial germ cell stage as is apparently the case in the alternating generations of the gall wasps (Cynipidae).

The critical period in the ontogeny of the ant in which the worker caste is differentiated has been a moot question for many years. The following discussion is an attempt to delimit this period and to outline the probable mechanism involved.

THE CRITICAL PERIOD DELIMITED.—As is well known, all ants are organized into societies. These societies or colonies, except in certain parasitic species, consist largely of the worker caste. The workers, all of which are females, perform all the essential social functions except reproduction. The production of worker females and of males, and the reproduction of sexually complete females, are functions of the queen.

The occurrence of the worker caste in ants is obviously an adaptive phenomenon, a colony response to environmental conditions. The adaptiveness of caste formation is based on the capacity of a single queen to repeat a production sequence of workers, soldiers, males, and queens (Haskins & Haskins, 1950; Schneirla, 1948). It is significant that the queens of certain parasitic species whose colonies are supported by the host colonies rarely if ever produce workers. Presumably the parasitic larval brood receives the same food as the host brood.

Since the worker caste is characteristic of all nonparasitic ants, irrespective of the wide variation in the larval nutrition of the various species, it is evident that any trophic influence on caste formation must be made effective through an agency common to all ant colonies. Such an agency is most likely to consist of a set of conditions resident in the queen. Morphological differentiation would be initiated therefore prior to egg deposition.

Within the queen ant, as in the sexually complete females of other Hymenoptera that are biparental in reproduction, all the ovarian eggs are genetically alike to the extent that if deposited unfertilized they become males. It is evident therefore that

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the worker caste which is entirely female is determined between the ripening of the ovarian egg and blastoderm formation.

The egg, while in the queen, is subjected to two sets of conditions that may be immediately affected by environmental factors, one set prior to ovulation when the egg is enclosed in its follicular membrane, and one set after ovulation when on its way through the oviduct the egg is momentarily in position to receive a sperm from the spermatheca. Only the set of conditions prior to ovulation is trophic in character.

It appears therefore that in the ant caste formation is initiated in the ripe ovarian egg. As Whiting (1938) has suggested slight stimuli applied at a nutritive-effective period in the ant egg could account for the wide differences between the worker, soldier, and sexual female.

THE MECHANISM OF CASTE DETERMINATION.—In the social Hymenoptera, as in other forms such as *Microbracon* and *Sphecophaga*, ovulation is externally induced. External factors therefore determine the length of the period in which the ripe ant egg is exposed to trophic influence, an influence effected by a process of absorption.

In hymenopterous species in which oviposition is restricted to highly specialized conditions, the number of eggs absorbed often exceeds the number deposited. This is the case with a species in which the female has a relatively long period of egg deposition and in which the embryonic stage is nourished only by the nutritive material stored in the egg (Schneider 1941).

In the gravid female of such species the rate of oogenesis is influenced slightly, if at all, when the environment suddenly lacks sources of stimuli necessary for egg deposition.

Absorption of the hymenopterous egg ends either at ovulation or when the entire content of the egg is abstracted. The empty, collapsed egg shells remain within the ovarian tubules. Eggs with a fluid content, however, may be deposited. The wasp *Microbracon hebetor* (*Habrobracon*) deposits many sterile eggs, some of which contain only liquid and dry up quickly, and some of which are slightly shrunken although containing apparently normal yolk. In the latter normal cleavage and blastoderm formation can occur, although such eggs may not hatch (Whiting 1940). This inability to hatch is probably an extreme effect of nutritional deficiency.

It is significant that in hymenopterous species which are disinclined to oviposit prior to mating a relatively high proportion of the progeny of the unmated female do not complete their development. This habit, which seems to characterize social insects, has also been observed in the wasp *Melittobia chalybii* (Schmieder 1933, 1938). In this species the rate of oogenesis is probably the same before as after mating although oviposition proceeds much more slowly before mating than afterwards. Schmieder (1933) theorized that in the case of *M. chalybii* a certain percentage of the eggs develop parthenogenetically into males, while the remaining eggs cannot develop at all unless fertilized, and then produce females. This would be the case if the accession of sperm restored viability to eggs rendered sterile by the absorptive process. Nest conditions that tend to cause delayed ovulation of ripe eggs also tend to bring about the fertilization of all eggs as they pass through the oviduct. Ripe eggs deposited without having been delayed in ovulation develop into the reproductive forms.

Delayed ovulation as a determinant of polymorphism was first suggested by observations on *Sphecophaga* by Schmieder (1939). He observed that a female may produce on an individual host, two types of female progeny, one type spinning a tough, parchment-like cocoon and undergoing diapause, the other spinning a white, loosely woven cocoon and not undergoing diapause. The fact that the proportion of white-cocoon-spinning larvae increased with the number of parasites per host indicated that this differentiation was correlated with differences in rates of egg deposition. The production by a single female of two types of offspring differentiated by the capacity to undergo diapause was noted by the writer (Flanders 1935) in the wasp *Dibrachoides*, a species in which ovisorption is regulated by environmental conditions.

The amount of nutritive material removed from the ovarian egg varies with the period of its retention or the rate of ovisorption or both. It is possible that the rate of ovisorption is influenced by the relative humidities of the colony environment. Schneirla (1950) observed that queens in colonies of the army ant *Eciton* produce bisexual nonworker broods only

when first subjected to "effective" dry conditions. In this ant caste differentiation does not appear to be correlated with differences in rates of egg depositions (Flanders 1945).

The extraction of material from the ripe egg undoubtedly affects embryonic development and in the ant probably determines morphological differentiation. It is well known that the parasitic extraction of assimulated food from the prepupal queen ant causes it to become a worker-like adult.

The embryos of certain endoparasitic Hymenoptera which feed on the body fluids of the host because the egg is devoid of yolk may exhibit dimorphism. In the parasitic wasp *Coccophagus capensis*, the the embryos from fertilized eggs, when feeding on the body fluids of the coccid *Saissetia oleae* constructed a trophic membrane; the embryos from unfertilized eggs, however, did not construct such a membrane when feeding on the body fluids of its own species (Flanders, 1946). Doutt (1947, 1952) observed that two kinds of larvae develop from the fertilized egg of the polyembryonic chalcid *Copidosoma koehleri*. The trophic origin of this dimorphism is indicated by the fact that it occurs most frequently when the host *Gnorimoschema operculella* is in a certain stage of development.

If differentiation in the ant occurs in the egg after ripening, we should expect the degree of morphological differentiation to be greater than in the honeybee and wasps and less than in the gall wasps. This apparently is the case. The absorptive process would allow for the fullest expression of the polymorphic potentialities inherent in the germ plasm.

It can logically be concluded that in the ant the nutrition of the embryo determines which one of two or more inherited lines of development it will follow, the embryonic nutritional differences are the effects of incomplete ovisorption within the ovaries of the queen, and that the environment of the queen (colony conditions) regulates the amount or quality of nutritive material removed from the egg.

SUMMARY.—The determination and control of the worker caste in ants appears to be a function of the environment acting through the queen, the environment controlling the extent of ovisorption. Prior to ovulation the rate of ovisorption and the period of exposure of the ovarian egg to absorption may determine the amount or quality of food remaining in the egg and utilized by the embryo. It is by this means that the line of morphological development, into a worker or into a reproductive form appears to be determined.

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The Toxicity of Cedar Oil Vapor to Clothes Moths

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The toxicity of cedar oil vapor to clothes moths, as well as its value as a repellent, has been under consideration since the colonists discovered red cedar in abundance on the eastern coast. Back and Rabak (1922) quote authors, one as early as 1682, who attested to the popular belief that cedar dust and shavings protect woolen from moths and verminous insects and to the usefulness of red cedar wood for making cabinets and boxes for storing woolens because of its odor being offensive to insects.

About 1918 a series of investigations was initiated [Scott, Abbott and Dudley (1918); Back and Rabak (1922); Back (1923); Billings (1934); Herrick (1934); Abbott and Billings (1935); Burgess (1935).], the results of which denied any effective repellent value to cedar oil vapor and limited the effectiveness of cedar chests to the following"The value of cedar chests in protecting clothes lies in the fact that they kill the newly hatched or young larvae or worms of clothes moths. Cedar chests can not be depended upon to kill the moths or millers, their eggs, or the worms after they are one half to full grown or after they are 3 or 4 months old. Neither will the chest kill all the pupae or crysalids."

Burgess (1935) reported that, when the heart wood of the red cedar was put with infested wool in sealed boxes, some larvae were destroyed and some reached maturity, but the mature females did not deposit eggs, or if they did, deposited infertile eggs.

Although the investigations mentioned above indicate that the vapor of the oil of red cedar, *Juniperus virginiana*, is toxic to some extent to the clothes moth larvae *Tineola bisselliella* (Hum.) none of them show that any attempt was made to relate the concentration of the vapor, the duration of exposure, and the per cent kill. The purpose of the present investigation is to establish this relationship for larvae that are one half to full grown.

Methods and Procedures.—The vapor concentration of the oil was determined by the method of Hayward and Seymour (1948). Oil from the same lot was vaporized for each run. The per cent

Table 1.—Effects of cedar oil vapors on clothes moth larvae at various concentrations and exposures.

	Unexposed Controls							Exposed Larvae				
Run No.	Start	Alive	Dead	Lost	% Mortality	Conc. mg./l.	Hours Duration	Start	Alive	Dead	Lost	% Mortality
1	100	98	2	0	2	.25	12.0	100	72	28	0	25.0
2	17	17	0	0	0	.50	12.0	21	13	8	0	35.7
3	10	10	0	0	0	.94	12.0	11	0	11	0	100.0
4	20	19	1	0	5	1.8	24.0	10	3	7	0	68.8
5	40	34	4	2	10.5	1.9	24.0	8	0	8	0	100.0
6	20	19	1	0	5	.93	21.0	20	4	16	0	79.2
7						1.2	24.0	18	3	15	0	82.7
8						.64	19.5	20	0	20	0	100.0
9	10	10	0	0	0	.27	16.0	20	15	5	0	21.9
10	20	18	2	0	10	.63	20.0	20	5	15	0	74.0
11	10	10	0	0	0	1.54	19.3	20	0	20	0	100.0
12	10	10	0	0	0	.79	23.7	30	6	24	0	79.2
13	10	10	0	0	0	1.2	21.4	70	7	56	7	88.5
14	10	10	0	0	0	.6	13.0	40	28	10	1	23.1
15	20	19	0	1	0	1.2	8.0	40	2	38	0	94.9
16	10	5	5	0	50	1.56	8.0	55	9	46	0	82.9
17	10	9	0	1	0	1.08	1.0	38	14	24	0	61.6
18	10	10	0	0	0	.47	4.3	50	23	27	0	51.9
19	20	20	0	0	0	.45	5.0	80	17	63	0	77.9
20						.45	16.0	33	2	31	0	93.7
21	10	9	0	1	0	.79	24.8	64	0	64	0	100.0
22	15	13	0	2	0	.19	21.5	40	33	4	3	7.0
23	16	16	0	0	0	.29	21.6	33	26	7	0	17.7

kill was determined by holding the cloth circle (in a petri dish) infested with the exposed larvae, some of which had woven tunnels, at a distance of one inch from a 40 watt electric bulb. After two minutes those that had not moved were counted as dead. Those that had escaped from the petri dish were subtracted from the number exposed and were not counted as dead or alive. The count was made approximately twelve hours after the exposure ceased.

The duration of exposure varied from 1 to 25 hours.

The exposure chamber was a box 33 by 18.5 by 16 inches, with a tightly fitted hinged door. The box stood on end and had a 7.5 inch shelf fastened to the center of each of the side-walls, leaving a 3.5 inch open space between the shelves in the center of the box. A third shelf, $10\frac{1}{2}''$ wide and supported by brackets from the back wall, was centered eight inches above the open space between the lower shelves. Between this third shelf and each side wall was an open space 4″ wide. This shelf was used as a baffle. The larvae were placed on the two lower shelves. The air samples were withdrawn from the center of the box at the level of the two lower shelves. The oil was vaporized by a hair dryer placed inside and on the bottom of the box. A Minneapolis Honeywell Regulator Company Type TA42 thermostat was mounted in the cabinet near the top and set at 80 degrees F.

The vaporizer was a Kenmore Electric Hair Dryer, Model 243.8304. An extension nozzle, a cylinder approximately 4″ long and 2″ in diameter, was made by replacing the ends of a can with wire screens. In this cylinder were placed cubes cut from a cellulose sponge and soaked in the cedar oil. The wiring to the heater unit was separated from the blower circuit in the hair dryer and each circuit controlled by rheostats so that the velocity and the temperature of the air stream passing over the sponges could each be varied The power to both circuits passed through the thermostat making the action of the vaporizer intermittent, operating normally through a twenty minute cycle.

The air sample, 12 liters, was taken, one half at the start of each run and the other at the end. Both parts were drawn at constant rate through alcohol in three absorbers described by Nichols (1938).

The larvae used in these runs were from cultures of *Tineola bisselliella* (Hum), obtained from Wards Natural Science Establishment, Rochester, N. Y. The runs covered the period from Oct. 1949 to April 1951. Only larvae 5 mm in length or longer were used. The larvae used for exposure and for controls were placed on a circle of woolen cloth in the bottom of a 4″ petri dish. It was observed that they promptly sought the under side of the cloth. The controls were kept in a box of the same dimensions as the exposure cabinet, and in the same room. In runs Nos. 10 and 11, Table 1, a bottle fitted with a stopper and a tube was placed in the exposure cabinet. The tube passed through the cabinet to the outside air. In these runs, in addition to the outside controls ten larvae were placed in the bottle and allowed to suffer any temperature changes caused by the intermittent action of the vaporizer. No larvae died in either run.

The average mortality for the control runs was found to be 4 per cent. The per cent mortality in the exposed runs was calculated as follows: a number equal to 4 per cent of the starting number of larvae was subtracted from both the starting number and the number dead. The per cent mortality was then calculated using these adjusted values.

RESULTS OBTAINED.—The results obtained by these procedures are shown in detail in table 1.

The work of Bliss (1940) indicates that insect toxicity data can be fitted by an equation of the type, probit $= A + B \log (C - C_0) + D \log t$, where C is the vapor concentration of the insecticide, C_0 is the threshold concentration, t is the time of exposure, and A, B, D are constants. The relation between probit and per cent mortality is expressed by the equations:

$$\text{Per cent mortality} = \frac{100}{\sqrt{2\pi}} \int_{-\infty}^{x} e^{-x^2/2} dx$$

$$\text{probit} = x + 5.$$

Probit and per cent mortality can be readily interconverted with the help of a table of probability functions.

The constants A, B, D were evaluated by the method of least squares; obtaining the best fit for the probit equation.

Table 2.—Empirical and calculated probits.

Run No.	w	C mg./ltr.	t hrs.	% Mortality Empirical	Probit Emp.	Probit Calc.	d e–c
1	10.0	0.25	12.0	25.0	4.32	4.39	−0.07
2	2.1	0.50	12.0	35.7	4.63	5.43	−0.80
3	1.1	0.94	12.0	100.0	*6.70	6.10	0.60
4	1.0	1.80	24.0	68.8	5.49	6.90	−1.41
5	0.8	1.90	24.0	100.0	*6.54	6.94	−0.40
6	2.0	0.93	21.0	79.2	5.81	6.24	−0.43
7	1.8	1.20	24.0	82.7	5.94	6.52	−0.58
8	2.0	0.64	19.5	100.0	*6.96	5.84	1.12
9	2.0	0.27	16.0	21.9	4.22	4.62	−0.40
10	2.0	0.63	20.0	74.0	5.64	5.83	−0.19
11	2.0	1.54	19.3	100.0	*6.96	6.70	0.26
12	3.0	0.79	23.7	79.2	5.81	6.11	−0.30
13	6.3	1.20	21.4	88.5	6.20	6.49	−0.29
14	3.8	0.60	13.0	23.1	4.26	5.66	−1.40
15	4.0	1.20	8.0	94.8	6.63	6.23	0.40
16	5.5	1.56	8.0	82.9	5.95	6.47	−0.52
17	3.8	1.08	1.0	61.6	5.30	5.58	−0.28
18	5.0	0.47	4.3	51.9	5.05	5.08	−0.03
19	8.0	0.45	5.0	77.9	5.77	5.07	0.70
20	3.3	0.45	16.0	93.7	6.53	5.38	1.15
21	6.4	0.79	24.2	100.0	*7.43	6.12	1.31
22	3.7	0.19	21.5	7.0	3.52	3.79	−0.27
23	3.3	0.29	21.6	17.7	4.07	4.82	−0.75
	82.9						

* Estimated by assuming a mortality of one individual in a run twice as large.

The necessary simultaneous equations were derived using the method described in Klotz (1950). They were:

$$(1) \qquad A\Sigma w + B\Sigma wx + D\Sigma wz = \Sigma wy$$

$$(2) \qquad A\Sigma wx + B\Sigma wx^2 + D\Sigma wxz = \Sigma wxy$$

$$(3) \qquad A\Sigma wz + B\Sigma wxz + D\Sigma wz^2 = \Sigma wyz^2$$

where $x = \log\ (C - C_0)$, $y =$ probit, $z = \log t$, and $w =$ the weighting given the individual run (based on the number of larvae in the run).

Calculations were carried out using the estimated value of $C_0 = 0.15$ and the following equation was obtained:

$$\text{probit} = 5.64 + 1.91 \log\ (C - 0.15) + 0.61 \log t$$

where concentration is expressed in mg./ltr. and time is expressed in hours. The above equation was found to fit the measured results within a probable error (50 per cent) of 0.50. The results are shown in Table 2. Using the probit equation as a basis, the concentrations required for probits of 4 through 8 were calculated as a function of the time of exposure. These results are shown in Table 3.

Table 3.—Concentration as a function of probit and time.

Probit	Probability of Mortality to Individual	Concentration (mg./ltr.) t=1 hr.	t=8 hrs.	t=1 day	t=1 week
4	0.1587	0.288	0.221	0.200	*0.177
5	0.5000	0.611	0.387	0.317	*0.240
6	0.8413	1.695	0.945	0.709	*0.450
7	0.9772	—	*2.81	*2.02	*1.16
8	0.9987	—	—	—	*3.51

* These values are outside the range of data used in calculating the basic equation—hence they are less dependable.

SUMMARY.—The work of Haywood and Seymour (1948), has indicated that the concentration of cedar oil vapor in a cedar chest may range up to 0.6 mg./ltr. The results of our work indicate that a concentration of 0.6 mg./ltr. with an exposure time of one week will give an average of 91.0 per cent mortality for half-grown larvae. In a cedar chest the time of exposure could be considerably longer, and this would probably increase the mortality or decrease the concentration necessary to produce the same mortality.

It may be noted in Table 3 that concentrations of 1.00–2.00 mg./ltr. are quite effective over as short a period as 8–24 hours. These concentrations can be produced in a clothes closet with a blower similar to that used in this experiment.

In our opinion this work furnishes strong evidence that cedar oil vapor at a sufficient concentration and exposure time will kill the half grown larvae of *Tineola bisselliella* (Hum.). The accuracy of the equations and tables relating probit, vapor concentration and exposure time is limited by the large probable error, and care must be exercised in any extrapolation of these results to higher concentrations and longer exposure times than were obtained in these experiments.

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Cantaloup Production with Honey Bees

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The commercial cantaloup grower is interested in producing the greatest quantity of the best quality of cantaloups. He gives close attention to the various cultural factors and to the control of diseases and harmful insects. However, he usually leaves the pollination of the crop to chance but, at times, he destroys the insect pollinators by applying insecticides while the plants are in bloom. This has been true even when the expanding agricultural and intensified insecticidal programs have tended to deplete the supply of pollinators.

That pollinators are required on cantaloups was emphasized by Rosa (1924), who showed that, although the hermaphroditic flowers of the cantaloup are self-fertile, they generally require the transfer of pollen from stamen to stigma by an outside agent to produce a melon and that wind is not a factor in this transfer. His continued studies (Rosa & Garthwaite 1926, and Jones & Rosa 1928) brought increasing insistence that honey bees are necessary for the commercial production of cantaloups.

To determine the value of various levels of bee populations to melon production and the interrelation of bees and melon flowers, the following experiment was conducted.

EXPERIMENTAL PROCEDURE.—A randomized-block experiment was set up on 16 plots, each 10 by 20 feet, in a 43-acre field of the MR-45 variety of cantaloups in the Salt River Valley of Arizona in 1950. Four bee treatments were replicated four times as follows: (1) Plots caged, bees present continuously; (2) plots caged, bees excluded; (3) plots caged, bees excluded until after the crown flowers had largely disappeared, then admitted; hereafter referred to as "post-crown"; and (4) plots open, pollinators left to chance.

Cages of the type described by Pedersen *et al.* (1950) were placed over the plots on May 1, prior to opening of the first flowers. They were removed on June 9 after flowering had largely ceased, five days before the beginning of harvest. In the first treatment a colony of honey bees was maintained in each cage continuously. Bees were excluded throughout the second treatment and from the third treatment until after most of the crown flowers had dropped, on May 18, after which a colony of bees was admitted to each cage of this treatment. In the fourth treatment, plots open, pollination was left to chance, although within a three-mile radius of the plots there were 137 colonies of bees and 1800 acres of melons. This proportion of colonies for the entire area was not unlike that in the 43-acre field containing the experimental plots. This field had 3 colonies of bees on its border, or one colony to 14 acres.

Each plot included 4 rows 5 feet apart and 10 feet long. Each row was thinned to 10 plants 1 foot apart, or 40 plants per plot. One plant in each row of each plot was randomly selected for detailed study, although all melons from all plots were harvested and graded.

[1] In cooperation with the Arizona Agricultural Experiment Station and the Arizona Vegetable Growers Association.

Appreciation is expressed to Orin A. Hills, of the Bureau of Entomology and Plant Quarantine, for counsel and active assistance; and to Clarence L. Benson, secretary of the Arizona Beekeepers Association, for the honey bees used in this experiment.

Table 1.—Marketable melons and culls produced on all plots. Arizona, 1950.

Plot Treatment	Marketable Melons		Culls		
	Number	Crates Per Acre	Number	Per Cent Sunburned	Per Cent Undersize
Caged plots:					
Bees continuous	180	274	94	46	53
No bees	4	7	27	4	96
Bees post-crown	184	272	136	41	56
Open plots:					
Chance pollination	145	213	95	32	65
Difference required for significance:					
At 5 per cent level	59	98	26		
At 1 per cent level	84	141	37		

Two weeks before flowering all the plots were dusted with a mixture of DDT and parathion, as a general insect-control measure. During the experiment an aphid infestation which developed on one row in one cage was controlled with parathion. A few plants became infested with spider mites toward the end of the experiment, but the infestation was not serious enough to warrant treatment. After the cages were removed all plots were dusted with parathion for protection against the spider mites.

The use of cages is often questioned because of possible effects on plant growth. Plastic screen cages, made of 12-mesh netting, were used and no significant differences were found in plant growth, flowering habits, soluble solids, or days for development from flowering to mature fruit, whether the plants were inside or outside the cages. Any factors that differed can therefore be attributed to the presence of more or fewer bees.

One-story, 10-frame colonies of honey bees, well supplied with stores and brood, were used in the cages. Water and 50–50 sugar water were supplied in poultry founts. Pollen cakes, placed over the brood nest, and water were supplied ad libitum. Sugar sirup was fed when necessary. Measurements of brood, pollen, and honey showed rapid decrease, but the colonies continued to function and recovered rapidly after being removed from the cages. The bees were gentle after the first few days of confinement, and observations thereafter were made without the use of a bee veil or smoker.

Results.—*Marketable Melons.*—The production of melons is shown in table 1. On caged plots from which bees were excluded only 4 marketable melons were obtained from 160 plants. On similar plots caged with bees 180 marketable melons were produced. This highly significant difference establishes the necessity of bees in commercial melon production. On the open plots subject to chance visitation by pollinators the number of marketable melons did not differ significantly from the number produced in the cages with bees, but suggests that production might have been increased with more bees. In the post-crown bee treatments no melons were set until the bees were introduced; then melons set rapidly and at harvest time the production was not significantly different from that in the other bee cages.

In treatments where bees were present during early flowering melons tended to set nearer the crown. These melons were sweeter,[1] as indicated by a highly significant negative correlation ($r = -.363^{**}$, $df = 55$) between distance of the melon from the crown and its soluble solids. The percentage of soluble solids of melons from the post-crown cages was significantly lower at the 1 per cent level than of melons from the other treatments.

Culls.—Practically all the culls were classified as such because they were sunburned or undersized. Undersize accounted for the highest percentage of the culls in all treatments. This high percentage reveals the relation of bee concentration to small melons (Table 1).

Seeds.—A count was made of seeds in all melons taken from the random plants. A mean of 586 seeds per melon in the post-crown plots was not significantly different from a mean of 552 seeds per melon from plots having bees continuously. The difference between the mean of 552 seeds and

[1] Sweetness is expressed as the percentage of soluble solids read directly from the refractometer.

Table 2.—**Bee visitation to cantaloup flowers in the open field and nectar production of flowers from the beeless cages. Arizona, 1950.**

Bee Visitation in the Open Field			Nectar Production Per Flower From Beeless Cages			
			Staminate		Hermaphroditic	
Hour	Bees, Thousands Per Acre	Pollen Collectors, Per Cent	Nectar, Milligrams	Sugar, Per Cent	Nectar, Milligrams	Sugar, Per Cent
A.M.						
7	0	0	—	—	—	—
8	300	53	1.8	—	1.8	—
9	1,900	53	—	—	—	—
10	1,900	52	2.7	—	2.7	—
11	2,700	45	—	—	—	—
12	1,500	22	—	—	—	—
P.M.						
1	1,200	19	1.2	—	16.7	—
2	900	6	—	53	—	36
3	500	0	—	—	—	—
4	200	0	2.2	56	17.9	27

a mean of 469 seeds per melon from the open plots was highly significant. This difference would indicate an intimate relationship between bee concentration, pollination, and seed production. The highly significant correlation ($r = 0.521^{**}$, $df = 55$) between seeds and size of melons indicates the influence of pollinators on size of fruit. Generally, melons that contained fewer than 400 seeds were below market grade or misshapened.

In the beeless cages 21 of the 160 plants set 31 melons, 26 of which were small and inedible culls. They had an average of 78 mature seeds. The other 5 melons, 1 of which was classed as a cull because of sunburn, had an average of 387 seeds. These melons were tagged on a day that the plots were irrigated, and bees that floated into the cages were subsequently seen visiting caged flowers. The low seed counts, the relation of seeds to size, the relation of undersized culls to the absence of large numbers of bees, and the low production in the beeless cages show the necessity of adequate bee visitation.

FLOWER-BEE RELATIONSHIP.—The ratio of staminate to hermaphroditic flowers varied from day to day, but for the season was 10 to 1. Bees visited both types indiscriminately and were observed visiting consecutive plants on a row more frequently than shifting from row to row. The number of visits required to accomplish thorough pollination of the hermaphroditic flower is unknown, but the evidence indicates that more than one visit is required. At least one viable pollen grain must reach the stigma for each seed that develops. This pollen may come from either type of flower.

In the staminate flower, with its short corolla tube, the nectar supply is within easy reach of the honey bee proboscis. In the hermaphroditic flower, however, the deep nectar supply and the constricted corolla tube opening, crowded with the stigma and anthers with their plume-like projections, prevent objects larger in diameter or shorter than the honey bee proboscis from reaching the nectar. When the bee proboscis rubs over the stamens, a mass of pollen is accumulated on the upper ventral portion. When the next hermaphroditic flower is visited, this pollen is rubbed onto the exposed stigmatic surface and pollination results. The construction of the melon flower and of the bee proboscis explains why the honey bee is practically the only pollinator of cantaloups.

In Arizona the cantaloup flowers open between 7 and 8 a.m. and close in the afternoon of the same day. Each flower is open but one day. Soon after the flower opens the stamens dehisce and nectar secretion begins. Flowers were collected at various times and the nectar was extracted centrifugally, weighed, and the per cent of sugar determined with a refractometer. These results are shown in table 2. By 11 a.m. about 3 milligrams of nectar had been secreted. Then, in the staminate flower, nectar secretion apparently ceased and, when it was not collected, evaporation concentrated the nec-

Table 3.—Comparison of nectar-yielding capacities of cantaloup and alfalfa flowers.

CANTALOUPS, SALT RIVER VALLEY, ARIZONA, 1950				ALFALFA, NEWTON, UTAH, 1948		
Date	Vine Length, Inches	Flowers Per Acre, Hundreds	Nectar Per Acre, Pounds	Date	Flowers Per Acre, Thousands	Nectar Per Acre, Pounds
May 5	5	43.6	0.3	Aug. 5	37,897	138
10	8	69.7	.6	12	53,187	194
16	13	113.3	.9	18	64,991	238
25	25	217.8	1.7	26	51,008	186
				Sept. 3	14,810	54

tar to about 56 per cent by late afternoon. Secretion in the hermaphroditic flower continued, however, and by late afternoon when not collected by bees (as occurred in the beeless cages), an average of 18 milligrams had accumulated. At times, when the nectar was not removed, it filled the corolla tube to overflowing. The sugar concentration of nectar from the hermaphroditic flowers did not exceed 36 per cent.

Pollen and nectar collection by the honey bees, both in the cages and outside, usually began as soon as the flowers opened. Pollen collection reached a peak by about 11 a.m. and tapered off rapidly after midday with little collection after 2 p.m. Nectar collection also reached a peak about 11, but tapered off much less rapidly with some activity as late as 6 p.m.

THE CANTALOUP AS A HONEY PLANT.—In Arizona cantaloup flowers are regarded as a minor source of a less desirable quality of honey by some beekeepers in the melon area, while others report good flows at times. One beekeeper who has operated in the area for several years reports that bees get little or no nectar until the end of the flowering period and then only if the humidity is high.

The three colonies beside the cantaloup field lost weight until the last of the flowering period when alfalfa was coming into bloom. Examination of the stored honey at the termination of the experiment revealed a mixture of cantaloup and alfalfa honey. The ratio of 14 acres of cantaloups per colony of bees in the vicinity and the low production of honey indicate that cantaloups are unimportant as a honey source, especially during early flowering.

The potential nectar-yielding capacity per acre of cantaloups and alfalfa is shown in table 3. Although the melon flower produces about twice as much nectar as the alfalfa flower and the concentration of sugars is similar, alfalfa has about 300 times as many flowers per acre as cantaloups. This explains the relative value of the two plants as sources of surplus honey.

POLLINATION VALUE OF OTHER INSECTS.—Thrips, beetles, and native bees (bumble bees and solitary bees) are often mentioned as pollinators. About 200 flowers, predominantly from the beeless cages, came under close scrutiny and most of them were harboring thrips. Occasionally this insect was seen with a pollen grain adhering to it but, in general, the thrips crawled over the sticky pollen mass without disturbing the pollen grains. Presence of thrips in the flowers failed to set a crop of melons in the beeless cages, an indication that they were not a factor in melon pollination.

Ladybird and various other smaller beetles were seen on all plots. None had mouth parts fitted for effective pollination of melons nor did their activities indicate that they were of any value as pollinators.

During two days spent recording all visits to marked flowers in the open, 586 honey bee visits were recorded, but only four native bees were seen. The honey bee visited successive flowers on the row, but each native bee visited only 1 flower, then disappeared, and, most significantly, only staminate flowers were visited. The other few native bees seen in the field were flitting over the vines instead of from flower to flower. In the area under observation native bees cannot be considered a factor in the pollination of melons.

Various other unidentified insects sufficiently small to pass in and out through the 12-mesh netting of the cages were of no practical value, although they may have set the culls in the beeless cages. The evidence is conclusive, therefore, that the grower must depend upon the

honey bee for commercial production of cantaloups.

Insecticides and Pollinators.—Too often the grower has given pollinators no consideration when attempting to control harmful insects with insecticides. As a result, the damage caused by killing the pollinators might have been as great as the damage by the harmful insects. In addition, experience has shown that some growers apply insecticides as a general precautionary measure without determining definitely that the use of these materials is necessary. If careful examination of the crop discloses that they are needed the damage to pollinators may be reduced by the following practices:

(1) In so far as possible apply the insecticide before the melons begin flowering; (2) use materials least toxic to bees that will control the harmful insects; (3) use the minimum dilution and poundage of insecticide that will control the insect pest involved; (4) apply after 6 p.m. or before 7 a.m.; and (5) avoid drift of insecticide onto plants attractive to bees.

Colonies Per Acre.—The number of colonies essential for ample pollination is of primary interest to melon growers. This experiment shows that bees are necessary, but it does not establish the colony-per-acre requirement for maximum production.

One colony per acre is the rule in fruit orchards and in seed fields of Ladino clover, and it is suggested that this is adequate for maximum cantaloup production. The colonies should be located on the edge of the field by the time the first flowers appear.

Summary.—In the Salt River Valley of Arizona a randomized block experiment on cantaloups with four types of bee treatments was maintained with the use of honey bee colonies and large plastic-screen cages. Studies were made of bee activity on cantaloup flowers and its effect on melon production.

Commercial production of cantaloups without the aid of pollinators was impossible. Honey bees were the only pollinators present in the area. Melon production was increased by placing honey bee colonies in the cages with the cantaloup flowers. Under these conditions the melons set nearer the crown and were sweeter, larger, and had more seeds than those produced in the open plots.

The percentage of soluble solids in the melons was negatively correlated with the distance from the crown. Size was correlated with the number of seeds. Melons containing fewer than 400 seeds were usually below market size and misshapen. Undersize culls were associated with insufficient bee visitation.

The melon flower opened between 7 and 8 a.m. and nectar secretion began at once. About 3 milligrams of nectar was produced by 11 a.m. after which secretion apparently ceased in the staminate flower. In the hermaphroditic flower secretion continued into the afternoon, a total of 18 milligrams being produced.

Bee activity began soon after the flower opened and reached a peak shortly before noon, with little activity in the afternoon. Individually, the cantaloup flower produced twice as much nectar of about the same sugar content as did the alfalfa flower, but alfalfa produced 300 times as many flowers to the acre. Cantaloup flowers were attractive to bees, but provided little honey for the beekeeper.

Thrips, beetles, and native bees proved to be ineffective in cantaloup pollination.

Care in the use of insecticides is necessary to protect pollinators.

One colony per acre is suggested as being adequate to insure thorough pollination of cantaloups.

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Microbial Infections in European Corn Borer Larvae Held in the Laboratory[1]

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In laboratory studies of the European corn borer, *Pyrausta nubilalis* (Hbn.), it is frequently necessary to hold large numbers of the borers in storage to permit their further development or to allow for the emergence of parasites. In such circumstances it is not unusual to find diseased corn borer larvae in greater or smaller numbers. The factors and conditions that determine the occurrence and extent of such infections are not well-known; nor has there been any comprehensive investigation of the nature and specific cause of most of these infections. In order to take a preliminary step toward gathering information on these matters, a brief study was made of 274 diseased European corn borer larvae submitted to our laboratory by W. G. Bradley and K. D. Arbuthnot from USDA laboratories in Ohio and Iowa between the dates of January 21 and August 10, 1950. The larvae had been collected originally from various points in Iowa and Ohio, but infected specimens were not apparent until after the insects had been held for a while in the USDA laboratories.

Most of the diseased specimens we received were selected by Mr. Arbuthnot who packed and shipped them by air mail to our laboratory as soon as possible after their death. Upon receipt, each larva was examined for the presence of bacteria, fungi, protozoa, and viruses. None of the specimens showed evidence of infection by a recognizable virus, but bacteria, fungi, and protozoa were found, separately or concomitantly, in most of the specimens submitted.

Of the 274 corn borer larvae submitted during this study, 236 were found to be hosts for microorganisms of one type or another, 34 were negative in this regard, and 4 specimens were lost through breakage of the vials containing them. Of the several kinds of microorganisms isolated from the larvae, strains of fungi of the genus *Beauveria* were isolated in 138 instances (45 per cent), bacteria in 91 instances (30 per cent), microsporidia (protozoa) in 67 instances (22 per cent), and miscellaneous fungi in 8 instances (3 per cent). In numerous cases at least two types of microorganisms occurred in the same insect.

The number and per cent of larvae that were hosts to the various types and combinations of microorganisms are shown in table 1. It is noteworthy that a frequent combination was that of *Beauveria* (fungus) and microsporidia (protozoan).

KINDS OF MICROORGANISMS ISOLATED.—Following a routine microbiological examination of each of the European-corn-borer specimens received, an attempt was made, in a preliminary way, to identify most of the forms isolated.

The majority of specimens harboring fungi appeared to be infected with *Beauveria bassiana* (Balsamo) Vuillemin. In addition, certain atypical forms and cultures that tended to resemble *Beauveria globulifera* (Speg.) Pic were also isolated. (It may be mentioned that previous to the initiation of this study, a group of specimens containing *Beauveria*-infected European-corn-borer larvae, collected in Iowa and held in the laboratory were received from J. H. Lilly on January 30, 1950.)

[1] Contribution from the Laboratory of Insect Pathology, Division of Biological Control, College of Agriculture, University of California, Berkeley 4, California.

Table 1.—Types and combinations of microorganisms found in 274 European corn borer larvae submitted for diagnoses.

TYPES OF MICROORGANISMS	NO. OF SPECIMENS	APPROXIMATE PER CENT OF TOTAL RECEIVED
Beauveria alone	77	28
Microsporidia alone	17	6
Bacteria alone	72	26
Miscellaneous fungi	7	3
Beauveria and microsporidia	44	16
Beauveria and bacteria	12	4
Beauveria, microsporidia, and bacteria	5	2
Bacteria and microsporidia	1	0.4
Bacteria and miscellaneous fungi	1	0.4
Negatives	34	12
Specimens lost	4	1

The fact that *Beauveria bassiana* occasionally causes considerable mortality in corn borers held in the laboratory has been noted previously (*e.g.*, Lefebvre, 1931; Baker *et al.*, 1949). According to these authors, no instance has been recorded of a borer being killed by this fungus, except under circumstances traceable to artificially imposed conditions. While they conclude that no lasting effect has resulted from the artificial dissemination of the fungus, this does not, of course, rule out the practicability of successfully using such organisms by processes of reapplication or reintroduction.

In all instances in which microsporidia were found, only one species appeared to be represented. This was found to be similar in its main characteristics to a species described by Paillot (1928) under the name *Perezia pyraustae* Paillot. Accordingly we have considered it to be this species (Steinhaus, 1951b), and further details as to its taxonomic status will be published elsewhere by I. M. Hall of our laboratory.

The great majority of the 91 strains of bacteria found in the diseased borers were gram-negative small rods. Of these 48 were selected for detailed cultural study. Of the 48 strains, 22 proved to be coliform bacteria (*i.e.*, lactose-fermenting, gram-negative small rods), while 26 of the strains were gram-negative small rods not having the ability to ferment lactose. The coliform bacteria were largely of the genus *Aerobacter*, most (15) of them having the essential characteristics of *Aerobacter cloacae* (Jordan).

The nonlactose fermenters were more difficult to identify with certainty. The 26 such strains could be reduced to 4 or 5 distinct species, representing probably 3 genera: *Pseudomonas*, *Alcaligenes*, *and Achromobacter*. The 12 strains of *Pseudomonas* were not identified as to species. Five of the *Alcaligenes* strains closely resembled the "Bergey Manual" description of *Alcaligenes bookeri* (Ford). Although in accordance with published descriptions our strain liquefied gelatin, a strain of *Alcaligenes bookeri* obtained from the American Type Culture Collection did not liquefy this substrate. It is also possible that our strains are close to *Achromobacter delicatulum* (Jordan). This species was reported by the present author in 1941 from the alimentary tract of the Colorado potato beetle, *Leptinotarsa decemlineata* (Say). Since then, however, the systematics relating to the slow lactose-fermenters has become more clarified, and it now appears that the strain isolated from the potato beetle probably represents a coliform or paracolon bacterium.

Four strains of sporeforming bacilli were isolated, all of which fit the species pattern of *Bacillus cereus* Frankland & Frankland. Three of the strains were moderately pathogenic for the alfalfa caterpillar when tested in the laboratory; the fourth strain showed no such virulence. N. R. Smith, who examined these four strains, observed that in the case of the three pathogenic strains the spores had a tendency to lie obliquely in the sporangium, although not so pronounced as has been observed in the case of *Bacillus thuringiensis* Berliner (see Steinhaus 1951a, p. 366). The nonpathogenic strain did not show the oblique spore position. The exact relation, if any, of this phenomenon to pathogenicity remains to be determined.

ROLE OF MICROORGANISMS IN THE MORTALITY OF EUROPEAN CORN BORER LARVAE.—Inasmuch as the European corn borer does not occur in California, tests as to its susceptibility to the various microorganisms herein reported could not be made at our Berkeley laboratory. Quarantine restrictions preclude laboratory studies in California with this serious agricultural pest. Accordingly, pathogenicity tests were run on other insect species [*e.g.*, *Junonia coenia* Hübner, *Colias philodice eurytheme* Boisduval, and *Laphygma exigua* (Hübner)]. In general, these tests indicated that the fungus, *Beauveria bassiana*, and the microsporidian, *Perezia pyraustae*, in all probability do constitute organisms pathogenic for insects such as the European corn borer. While it is possible that either of these organisms may cause infections secondary to adverse environmental or rearing conditions, nevertheless, they probably are important agents in the overall cause of mortality. None of the bacteria appeared to be the type that are ordinarily primary pathogens of insects. Their role as secondary pathogens has not been determined, but this is a distinct possibility in at least the 72 dead larvae in which bacteria were the only microorganisms observed. In most of these latter specimens the bacteria were present in

Spontaneous Infections[1]	Experimental Infections[2]
BACTERIAL INFECTIONS	
Bacillus canadensis (Chor.)	*Bacillus galleriae* No. 1 (Chor.)
Bacillus cazaubon Nos. 1 & 2 (M., E., & S.)	*Bacillus galleriae* No. 2 (Chor.)
Bacillus christiei (Chor.)	"*Bacillus sotto*" of Ischivata
Bacillus italicum Nos. 1, 2, & 3 (M., E., & S.)	*Bacillus subtilis* Cohn
Bacillus ontarioni (Chor.)	*Bacillus thuringiensis* Berliner
Bacillus pyrenei (M., E., & S.) [Black, brown, and pink strains]	*Microbacterium tuberculosis* (Schroeter
Bacterium ellingeri (M. & C.)	*Micrococcus* sp.
Bacterium gibsoni (Chor.)	*Proteus vulgaris Hauser* (strain OX-19)
Bacterium pyraustae Nos. 1–7 (M. & C.)	*Salmonella enteritidis* var. *Danysz* Bahr
Micrococcus curtissi Chor.	*Serratia marcescens* Bizio
Vibrio leonardii M. & C.	
FUNGUS INFECTIONS	
Beauveria bassiana (Bals.)	*Aspergillus flavus* Link
Mycoderma clayi M., E., & C.	*Aspergillus niger* Tieg.
	Beauveria globulifera (Speg.)
	Metarrhizium anisopliae (Metch.)
	Spicaria farinosa (Fron.)
PROTOZOAN INFECTIONS	
Leptomonas pyraustae Paillet = [*Herpetomonas pyraustae*]	*Thelohania mesnili* Paillot
Perezia pyraustae Paillot (probably synonym: *Nosema pyraustae* Kotlán)	
NEMATODE INFECTIONS	
	Neoaplectana glaseri Steiner

[1] The term "spontaneous infection" refers to those infections occurring in larvae not intentionally inoculated with the pathogen concerned.
[2] "Experimental infection" refers to infections induced by the direct inoculation or feeding of the pathogen concerned.

great numbers throughout the tissues. This situation could represent post-mortem invasion but such a condition also prevails in insects succumbing to primary or secondary bacterial infection.

It should be pointed out that in this study only bacteria, and in one instance a microsporidian, have been found in corn-borer larvae collected in the field and held in sterile vials until sent to our laboratory. Specimens from which fungi (*Beauveria*) were isolated had all been handled in the laboratory prior to their becoming diseased. Those larvae sprayed with tap water (to provide them with moisture required for normal development) appeared to be particularly subject to *Beauveria* infection.

LIST OF MICROORGANISMS RECORDED AS FOUND IN DISEASED EUROPEAN-CORN-BORER LARVAE.—In addition to the findings covered in the present report, the literature records a significant number and variety of microorganisms as being infectious for larvae of the European corn-borer. A brief perusal of the literature reveals the following species of bacteria, fungi, protozoa, and nematode cited in connection with either spontaneous or experimental infections of this insect. Most of these records have been made on the basis of European studies.

SUMMARY.—A study was made of the cause of death of 274 larvae of the European corn borer that died while being held in USDA laboratories in Ohio and Iowa. Infection and death of the larvae was found to be caused by certain fungi, protozoa, or bacteria, or combinations of these organisms. The principal fungus involved was *Beauveria bassiana* (Bals.), the principal protozoan was the microsporidian *Perezia pyraustae* Paillot, and bacteria of the genera *Pseudomonas*, *Alcaligenes*, and probably *Achromobacter* were isolated. No *Beauveria*-infected larvae were found in specimens collected in the field in sterile vials; laboratory handling did appear to increase the incidence of *Beauveria* infection, as well as the other types of infection which also were found occasionally in field collected specimens.

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The Degradation and Detoxication of Parathion in Dairy Cows[1,2]

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We have previously reported (Dahm *et al.* 1950) that no parathion was excreted in the milk, and that no harmful effects on the health of the cows were noted in dairy cows fed a commercially available parathion wettable powder in capsules at levels of 1 or 5 parts of parathion per million of the estimated dry roughage intake. The results of this rather heavy feeding of parathion prompted two additional considerations. First, would parathion fed as a residue on forage have a different effect than it would when fed as a wettable powder in capsules? Other investigators (Ely *et al.* 1950; Harris *et al.* 1949) have reported higher concentrations of DDT in the milk and fat of animals when fed DDT as a residue on a forage crop than when an equivalent dose of DDT was fed in capsules. Second, since no parathion was recovered in the milk at any time in the previous experiment (Dahm *et al.* 1950) involving a heavy feeding of parathion, the question of the metabolic fate of parathion remained unanswered. Therefore, an experiment was designed in which five dairy cows were fed alfalfa hay containing an abnormally high residue of parathion. A second experiment was performed to determine the metabolic fate of parathion when fed as a wettable powder in capsules to dairy cows in massive but always sublethal amounts.

It has been shown (Hazleton and Holland 1950) that when parathion was ingested in sublethal doses by experimental animals, it was not stored in the vital organs or in the body fat of the animal. Only when nearly lethal doses were administered was the chemical excreted in the urine and then only in very small amounts.

There are several interesting aspects involved in a study of the degradation and detoxication of parathion. Smith *et al.* (1932) stated that certain phosphoric acid esters such as tri-*o*-cresyl phosphate apparently are not hydrolyzed in the alimentary canal of the cat and are absorbed only with difficulty from the alimentary canal. Parathion is rather easily converted to *p*-nitrophenol and presumably diethyl thiophosphoric acid by alkaline hydrolysis. Aldridge,[4] after working on the mode of action of parathion and analogs (Aldridge 1950), suggested that parathion is hydrolyzed enzymatically *in vivo* to *p*-nitrophenol and diethyl thiophosphoric acid. Phenols in general are excreted through the urine in the form of conjugates with glucuronic or sulfuric acid, but especially with glucuronic acid

Paid Paper.

[1] Contribution no. 590, Department of Entomology and no. 206 Department of Dairy Husbandry. This work was supported in part by a grant of funds and equipment from the American Cyanamid Co., New York 20, N. Y. Parathion is O,O-diethyl O,*p*-nitrophenyl thiophosphate. Paper presented at the meetings of the American Chemical Society, Division of Agricultural and Food Chemistry, Boston, Mass., April 1–5, 1951.

[2] The data in this paper are taken in part from a thesis submitted by Joe E. Pankaskie in partial fulfillment of the requirements for the degree of Master of Science in Entomology, Kansas State College, Manhattan, Kansas.

[3] Present address is Julius Hyman & Co., Denver 1, Colorado.

[4] Aldridge, W. M., Personal Communication, November 1950. Based on work done by the Toxicology Unit, Medical Research Council, Serum Research Institute, Carshalton, Surrey, England.

(Garton & Williams 1949; Hawk *et al.* 1947; Malpress 1948; Porteous & Williams 1949, 1949a; Torda 1945; Venning 1938). Compounds such as *p*-phenetidine (*p*-ethoxyaniline) are excreted as conjugated phenols, the conjugation probably occurring after de-alkylation to the corresponding aminophenol (Smith & Williams 1949, 1949b). Aromatic nitro compounds may undergo reduction and subsequent acetylation and are excreted in that form (Bray *et al.* 1949; Guerbet & Mayer 1932). Nitrophenols are excreted as conjugates of glucuronic acid and the amino derivative of the nitrophenol (Guerbet & Mayer 1932). Thus, besides parathion, the following compounds should be considered in a study of its degradation and detoxication: the amino derivative of parathion (O,O-diethyl O,*p*-aminophenyl thiophosphate), *p*-nitrophenol (both free and conjugated), *p*-aminophenol (both free and conjugated), N-acetyl *p*-aminophenol, conjugated glucuronic acid, and diethyl thiophosphoric acid.

PROCEDURE.—*Experiment I—Preparation and Feeding of Alfalfa Hay.*—A field of first-cutting alfalfa was sprayed with a 25 per cent emulsifiable concentrate (American Cyanamid Thiophos X-2) at the heavy rate of approximately 0.8 pound of parathion per acre. The spraying was done in the morning, using a compressed air sprayer and an operating pressure of approximately 50 pounds per square inch. The alfalfa was cut early in the afternoon of the same day and samples for analysis were collected about 4:00 p.m. The alfalfa was raked twice to facilitate drying and was baled two days later. The baled alfalfa was removed immediately from the field and stored in a barn. No rain fell during the period of spraying, cutting, drying, baling and hauling. Four composite samples of alfalfa were collected in the four quarters of the field after cutting. Each of the four samples was composed of about 20 subsamples taken at random from each quarter of the field. The samples were brought into the laboratory and 200-gram samples were taken from each of the four field samples for separate analysis. Alfalfa on an unsprayed field about one-half mile from the sprayed field was cut and handled in a similar manner. The alfalfa from the unsprayed field was to be used later as feed for check groups of cows and as samples to which known amounts of parathion were added before extraction.

At the beginning of each weekly feeding period, the hay to be fed during the following week was set aside for sampling. A handful of hay was taken from each bale by jabbing an iron hook into the bale and removing a small amount of hay. Check samples were taken from untreated hay. All refused hay was stored in steel barrels until the end of each week, at which time samples were taken for analysis. Moisture determinations were made after drying samples in an electric oven to a constant weight. Field samples averaged approximately 65 per cent moisture and baled samples averaged about 10 per cent moisture.

The alfalfa samples were extracted according to a method previously described (Stansbury & Dahm 1951) with modifications for purifying the benzene (Gunther & Blinn 1950). The benzene extracts were decolorized according to the method of Gunther & Blinn (1950) except that 30 grams of the adsorbent mixture were used. If the color was not removed completely, that which remained was destroyed during the reduction reaction of the parathion determination. Aliquots of the decolorized benzene extract were used for analysis according to the Averell & Norris (1948) procedure. Of the known amounts of parathion added to the alfalfa before extraction, about 65 per cent recovery was obtained by using this procedure. Based on an average of the analyses of the four field samples, the alfalfa hay collected 5 hours after spraying had an average parathion content of 30 parts per million based on the freshly cut weight of the samples and 86 parts per million based on the oven dried weight of the samples. The parathion residue found in the bales averaged about 14 parts per million during the feeding experiment. Results of the weekly analyses during the feeding experiment are shown in table 1, each value being the average of at least two separate analyses. There was a much greater amount of residual parathion on this alfalfa than would normally be found after applying parathion for good insect control (Ginsburg *et al.* 1950). This was the result of an experimentally high rate of application and an abnormally short period of time between the spraying of parathion and the processing of the alfalfa. Consequently, the experi-

Table 1.—**Parathion residues on baled alfalfa used in the 61-day dairy cattle feeding experiment.**

WEEK OF FEEDING	WEIGHT BASIS[a]	PARATHION RESIDUE	
		Bale Sample	Refused Sample
		(ppm.)	(ppm.)
1st	air dry[b]	13.4	12.0
	oven dried	15.3	13.7
2nd	air dry	11.9	10.5
	oven dried	13.2	11.7
3rd	air dry	18.8	17.6
	oven dried	20.9	19.6
4th	air dry	12.7	17.0
	oven dried	14.1	18.9
5th	air dry	12.2	14.5
	oven dried	13.6	16.1
6th	air dry	13.8	15.3
	oven dried	15.3	17.0
7th	air dry	11.9	13.8
	oven dried	13.2	15.3
8th	air dry	16.3	10.0
	oven dried	18.1	11.1
9th	air dry	11.8	9.5
	oven dried	13.1	10.6
Av.	air dry	13.6	13.4
	oven dried	15.2	14.9

[a] The bale sample taken at the first week of feeding had an average moisture content of 12.5 per cent; all other samples taken during the experiment had an average moisture content of 10 per cent.
[b] As fed.

mental cows ingested more actual parathion than they would have by consuming alfalfa that had been treated and harvested under the usual insect control program.

It is interesting to note that under barn loft storage conditions, this baled alfalfa had a parathion residue of 4.7 parts per million based on its air dry weight and a moisture content of 9 per cent, approximately one year after baling.

Five dairy cows in mid-lactation selected from the College herd were fed the sprayed hay continuously for a period of 61 days. Hay was fed to the cows three times daily to encourage greater consumption, and weigh-backs of refused hay were made. A concentrate mixture containing 16 per cent protein was fed according to the cows' production. Breeds and weights of the cows and their average feed consumption and parathion intake are shown in table 2. Feeding began 27 days after application of parathion to the alfalfa in the field.

During this feeding experiment weekly samples of milk, jugular blood, and urine were collected for the determination of the presence of parathion and detoxication products. Cows for control samples were selected from the College herd in both experiments I and II.

Experiment II—Capsulate Feeding of Parathion.—In order to administer higher dosages of parathion than were possible in the residue-bearing forage feeding experiment, a Holstein cow was fed a commercially available 25 per cent parathion wettable powder daily in gelatin capsules. The dosage was based on the weight of the cow. The parathion was fed continuously over a period of 14 weeks. During the first week the cow received parathion at the rate of one milligram per kilogram of body weight per day. At this time the dosage rate was increased by 1 milligram of parathion per kilogram of body weight per day and the cow received parathion during the second week at the rate of 2 milligrams per kilogram of body weight

Table 2.—**Average parathion intake during the 61-day dairy cattle hay feeding experiment.**

Cow No.	Breed	Av. Weight	Hay Fed	Parathion on hay Fed	Hay Refused	Parathion on Refused Hay	Net Parathion Intake	
		(kg.)	(kg./day)	(mg./day)	(kg./day)	(mg./day)	(mg./day)	(mg./kg. body wt./day)
146A	Holstein	620	17.5	240.1	2.5	31.7	208.4	0.34
262A	Ayrshire	529	15.0	205.9	2.9	39.6	166.3	0.31
378A	Jersey	393	12.1	165.0	3.2	43.2	121.8	0.31
469A	Guernsey	531	15.1	207.2	2.4	32.6	174.6	0.33
498A	Guernsey	488	13.9	190.9	1.9	27.4	163.5	0.34
Av. all cows		512	14.7	201.8	2.6	34.9	166.9	0.33

per day. The parathion feeding rate was increased by 1 milligram per kilogram of body weight per day at the end of each week for the next 7 weeks until the cow was receiving parathion at the rate of nine milligrams per kilogram of body weight per day. During the tenth, eleventh, and twelfth weeks the cow received parathion at the rate of 12, 15, and 18 milligrams per kilogram of body weight per day respectively. The dosage was then increased to 24 milligrams per kilogram of body weight per day during the thirteenth week and finally, during the fourteenth week the cow received parathion at the extremely high rate of 32 milligrams per kilogram of body weight per day. This final high rate of parathion feeding is believed to be the highest reported in the literature for any experimental animal in which the animal survived. Later, to disprove the possibility of tolerance to parathion having been developed in the first animal, a second Holstein cow was fed parathion in a manner similar to the first cow at the heavy dosage of 16 milligrams per kilogram of body weight per day for a period of one week.

ANALYTICAL PROCEDURES.—*Milk Analysis.*—The liquid-liquid extraction technique previously reported (Dahm *et al.* 1950) was again used for the extraction of parathion from milk. The Averell and Norris (1948) method was then used for the determination of parathion in the petroleum ether extracts.

Preliminary investigations on the determination of *p*-nitrophenol were made by adding small amounts of the compound to milk and extracting in the liquid-liquid extraction apparatus. Much of the *p*-nitrophenol was extracted with the parathion even though the solubility of the compound in petroleum ether was very slight. Efforts were concentrated on separating these two compounds from the same milk sample using the liquid-liquid extraction procedure since a separate extraction for *p*-nitrophenol would involve a second sample of milk and an increase in the analytical time. The analytical method we used was developed by Giesecke[1] and is based on the yellow color of *p*-nitrophenol in alkaline solution. It was carried out as follows: the petroleum ether extract from the liquid-liquid milk extraction process was shaken with three 10-milliliter portions of 1 per cent aqueous Na_2CO_3 solution in a separatory funnel. The petroleum ether fraction was saved for parathion determination. The combined aqueous fractions containing the *p*-nitrophenol were transferred to a 50-milliliter volumetric flask. Five milliliters of 0.1 N aqueous KOH solution were added to the flask and the volume made up to the mark with water. The normality of the final solution should be approximately 0.01 N. If after adding the KOH the solution was slightly turbid or cloudy, it was cleared up by adding a few milliliters of 95 per cent ethyl alcohol to the flask. The alcohol dissolved the fine particles in suspension that caused the cloudiness. The per cent transmittance of the final solution was observed on a Coleman model 14 spectrophotometer using a wave length setting of 400 millimicrons. A milk blank was used for the 100 per cent transmittance setting. A standard curve was pared from the data obtained by adding known amounts of *p*-nitrophenol to the milk before extraction and analyzing the extract by the above procedure. This is essentially the same procedure of hydrolysis and analysis that was developed independently by Ketelaar & Hellingman (1951).

When small amounts of *p*-nitrophenol, ranging from 25 to 150 micrograms, were added to the milk about 60 to 70 per cent recovery was obtained, in comparison with the standard reagent curve. The use of either a stronger, e.g. 2.5 per cent, Na_2CO_3 solution or distilled water for the separation of *p*-nitrophenol and parathion produces an incomplete separation of the two compounds and reduces the final recovery of added amounts of parathion. The presence of both *p*-nitrophenol and parathion in the original milk does not interfere with the determination of either of the compounds. The color intensity of the *p*-nitrophenol in alkaline solution was not affected by varying the normality within the range of 0.006 N to 2 N KOH. The yellow color remained stable when left standing in alkaline solution for as long as 24 hours.

Blood Analysis.—Parathion and *p*-nitrophenol added to whole oxalated jugular blood were extracted from 25-milliliter samples in a separatory funnel with three

[1] Personal Communication, February 1, 1950, from Paul Giesecke of the Stamford, Connecticut (U.S.A)., laboratories of the American Cyanamid Company.

50-milliliter portions of a 1:1 benzene: diethyl ether mixture. This solvent extract was then extracted with aqueous one per cent Na_2CO_3 solution to separate the *p*-nitrophenol from the parathion. The *p*-nitrophenol was then determined by the method used for its determination in milk. The parathion in the benzene:diethyl ether solution was determined according to the Averell & Norris (1948) procedure. The use of the two solvents permits a recovery of 85–90 per cent of added amounts of the two compounds ranging from 25 to 150 micrograms of *p*-nitrophenol and 20 to 160 micrograms of parathion.

Although the blood of cattle has a very low cholinesterase activity compared to that of other animals (Stedman *et al.* 1933; Okabe *et al.* 1950), the electrometric method of Michel (1949) was used to determine the red cell and plasma cholinesterase activity of jugular blood samples taken from the Holstein cow fed parathion in capsules. Control blood samples were taken from another Holstein cow in the College herd.

Urine Analysis.—Diethyl ether was used as the solvent for extracting parathion, *p*-nitrophenol and *p*-aminophenol from cows' urine because of the high solubility of these compounds in this solvent and also because of the immiscibility of ether with normal urine. A 100-milliliter sample of urine was saturated with NaCl and placed in a separatory funnel. The mixture was extracted three times with 50-milliliter portions of diethyl ether. The ether extract was then used in the determination of one of the above compounds.

To determine *p*-nitrophenol, the ether extract was evaporated; the residue was taken up in water and transferred to a 50-milliliter volumetric flask. The colorimetric procedure was the same as that given for the determination of *p*-nitrophenol in milk. Mountain *et al.* (1951) recently have published a procedure for the determination of *p*-nitrophenol in urine in parathion poisoning cases which also employs the indophenol reaction following the reduction of *p*-nitrophenol to *p*-aminophenol.

In the process of working out a satisfactory method for the determination of parathion in urine, separatory funnel extracts of normal urine were made with benzene and diethyl ether and extracts were made with petroleum ether in the liquid-liquid extraction apparatus. By these methods some substance was extracted that gave an interfering magenta-like color following the diazotization and coupling steps in the Averell & Norris (1948) procedure for determining parathion. To avoid this interference, the possibility of analyzing for parathion by hydrolyzing it and subsequently analyzing for its hydrolytic product, *p*-nitrophenol, was investigated. The separatory funnel-diethyl ether extract was transferred to a 125-milliliter Erlenmeyer flask, the ether was evaporated and the residue was redissolved in 25 milliliters of 1:1 ethyl alcohol:water mixture. Three milliliters of approximately 10 N KOH were added and the mixture was refluxed in an all-glass system for thirty minutes. The solution was cooled, transferred to a 50-milliliter volumetric flask and diluted to the mark. Any turbidity at this point was eliminated by diluting the refluxed solution with 95 per cent ethyl alcohol instead of water. Transmittance readings were taken in the same manner as for the *p*-nitrophenol determination described above. Therefore, the amount of parathion present was calculated by multiplying the number of micrograms of *p*-nitrophenol found by the factor 2.093.

The method used for the determination of small amounts of *p*-aminophenol in biological tissue was that reported by Brodie & Axelrod (1948). The ether extract was evaporated and the residue was taken up in five milliliters of approximately 0.01 N HCl. The colorimetric procedure employing the coupling of *p*-aminophenol with phenol in the presence of sodium hypobromite was then carried out on the aqueous solution. This indophenol reaction produces a bright blue color, and a sensitivity of two micrograms was possible. The blue color in the indophenol reaction reached its maximum density in 20 minutes. The per cent transmittance was determined on the spectophotometer using a wave length setting of 620 millimicrons.

Analytical methods for determining conjugated phenols are based on the hydrolysis of the conjugated phenol into the phenol and glucuronic acid and subsequent determination of that phenol and of glucuronic acid (Brodie & Axelrod 1948; Porteous & Williams 1949). A convenient procedure is reported by Porteous & Williams (1949) in which concentrated

H_2SO_4 is added to urine until the resulting mixture is equivalent to about 10 N acid. This mixture is then refluxed for one hour. This method of hydrolysis was used on both urine and ether extracts of urine. After hydrolysis was complete the hydrolysate was neutralized with NaOH and buffered with K_2HPO_4 and then extracted with diethyl ether to remove the phenol. This ether extract was reextracted with five milliliters of approximately 0.01 N HCl and the dilute acid extract was analyzed for the presence of *p*-aminophenol.

The method used for detecting glucuronic acid was that reported by Hanson *et al.* (1944). This colorimetric procedure was used on samples of whole urine.

Determinations of diazotizable material in urine and in diethyl ether extracts of urine were carried out by adapting the diazotization and coupling reactions used in the Bratton & Marshall (1939) and the Averell and Norris (1948) procedures without employing the reduction reaction. This procedure was carried out on 5-milliliter samples of urine and on diethyl ether extracts of 100-milliliter samples of urine. In the latter case the ether was evaporated and the residue was taken up in water which was transferred to a 50-milliliter volumetric flask. If whole urine was used it was placed directly in the volumetric flask. All reagents were added directly to the flask. A urine blank was always used for the 100 per cent transmittance setting on the spectrophotometer at a wave length setting of 555 millimicrons. A color was obtained when normal urine was subjected to this reaction but analysis of urine from six separate check cows indicated that the concentration of diazotizable material in normal urine was quite uniform among the different cows, so that any increase in the color density from urine from experimentally-fed cows might be suspected of being due to detoxication products of parathion. Suspected detoxication products that will give a positive diazo reaction are the amino derivative of parathion and *p*-aminophenyl glucuronide (Smith & Williams 1949a).

A procedure reported by Smith & Williams (1949a, 1949b) was used in attempts to isolate crystalline *p*-aminophenylglucuronide from cow's urine. Their procedure results in a final solution from which they obtained a crystalline precipitate of *p*-aminophenylglucuronide in their experiments with rabbits dosed with aniline. Twenty liters of urine from a cow fed parathion in capsules at the rate of 12 milligrams of parathion per kilogram of body weight per day were processed according to this procedure to obtain the final solution.

RESULTS.—The alfalfa hay used in the forage residue feeding experiment contained an average parathion residue of approximately 14 parts per million as fed (Table 1). Although much of the hay had a musty odor, the average intake of this treated hay was 12.1 kilograms per cow per day or 2.36 pounds per 100 pounds of body weight (Table 2). The average intake of 0.33 milligram of parathion per kilogram of body weight per day (Table 2) was about three times higher than that previously reported for capsulate feeding (Dahm *et al.* 1950).

During the 61-day period of feeding treated hay to the dairy cows, neither parathion nor *p*-nitrophenol ever was found in either the milk or blood, and no parathion, *p*-nitrophenol or free *p*-aminophenol ever was found in the urine from these cows. Approximately 70 analyses of milk, 50 analyses of jugular blood, and 50 analyses of urine were made during this experiment.

By carrying out determinations of diazotizable material in the urine of six cows fed a normal ration it was discovered that the concentration of diazotizable material in their urine was quite uniform from day to day. By comparison, a marked increase in the intensity of the color due to diazotizable material was found in the urine of the five cows on the parathion forage residue feeding experiment. This increased color intensity persisted throughout the course of the parathion-treated forage feeding experiment and disappeared within five days after the cows were returned to a normal ration.

The cows used in the forage feeding experiment had been in lactation an average of 150 days at the beginning of the experiment. Average milk production decreased from 27.8 to 23.1 pounds daily during the 61-day experimental period. This decline of 16.9 per cent is considered to be within the normal range expected for cows in this stage of lactation. Average body weights increased from 1113 to 1124 pounds dur-

ing the experimental period. This slight increase is also considered normal for cows in mid-lactation.

All except one of the experimental cows had normal pregnancies during and following the experimental period. One cow was not pregnant at the termination of the experiment. She died of a cardiac puncture by ingested baling wire about six weeks later. It seemed apparent that the feeding of hay containing a heavy residue of parathion had no adverse effects on the milk production, weight, and general health of the cows. This is in agreement with the results of our earlier study (Dahm *et al.* 1950).

Because of the negative analytical findings in the milk, blood, and urine for parathion, *p*-nitrophenol, and free *p*-aminophenol in the first experiment, the detoxication of parathion was studied further by administering increasingly greater but always sublethal amounts of parathion, in the form of a commercial wettable powder formulation, in capsules to a dairy cow and intensifying the studies on the urine. It was found that the cow receiving parathion in capsules in increasing dosages, to a maximum of 32 milligrams of parathion per kilogram of body weight per day, excreted increasing amounts of diazotizable material. Efforts to separate the normal color-producing constituent(s) of the urine from the compound(s) causing the increased color intensity in the urine of the parathion-fed cows were unsuccessful. However, the diazo colors derived from parathion, from normal urine, and from urine from the experimentally fed cows had identical absorption curves with absorption maxima at a wave length of 555–560 millimicrons. The compound(s) causing the increased diazo color in the urine of the experimentally fed cows cannot be parathion because no reduction step is required before diazotization can be accomplished and no *p*-nitrophenol can be detected after alkaline hydrolysis. This color could be due to either *p*-aminophenol glucuronide or to the amino derivative of parathion.

The presence of a conjugated *p*-aminophenol seemed an attractive possibility because of the evidence in the literature (Guerbet & Mayer 1932). After either the ether extracts of urine or whole urine samples were subjected to stong acid hydrolysis and further treated as in the procedure for glucuronide hydrolysis, a positive test for *p*-aminophenol was obtained. This positive test does not necessarily indicate the positive presence of *p*-aminophenylglucuronide, as the amino derivative of parathion would also be hydrolyzed to *p*-aminophenol when subjected to such severe hydrolytic treatment. When small volumes of urine, collected during the week when two milligrams of parathion per kilogram of body weight per day were administered to one cow, were subjected to strong acid hydrolysis previous to the determination of *p*-aminophenol, about five micrograms of *p*-aminophenol per milliliter of urine were found. When the parathion was administered at the rate of 7 milligrams per kilogram per day, about 15 micrograms of *p*-aminophenol per milliliter of urine were found.

Normal cow urine apparently contains a small amount of glucuronic acid based upon a positive glucuronic acid test. However, if the color of the glucuronic acid test from normal urine was used for the 100 per cent transmittance setting on the spectrophotometer, the presence of excess glucuronic acid was indicated by readings as low as 30 per cent transmittance for the glucuronic acid test applied to samples of urine from the cow fed parathion as a wettable powder.

No *p*-aminophenylglucuronide could be induced to precipitate from the final solution after using the procedure reported by Smith & Williams (1949); however, *p*-aminophenol and glucuronic acid could be detected colorimetrically in the final solution after strong acid hydrolysis. These compounds were not found in the final solution from control urine. It is believed that the *p*-aminophenol and glucuronic acid found were hydrolytic products of *p*-aminophenylglucuronide present in the urine from cows ingesting parathion.

The *p*-nitrophenol is apparently reduced to *p*-aminophenol and conjugated to an appreciable extent with glucuronic acid and is excreted in the urine in this conjugated form. In this respect the behavior of *p*-nitrophenol follows that already reported for aromatic nitro compounds (Guerbet & Mayer 1932).

Although cholinesterase determinations were run routinely throughout the parathion capsulate feeding experiment, no reliable evidence was obtained indicative

of cholinesterase inhibition. When larger amounts of both red cells and plasma were used than are called for in the Michel (1949) procedure the results were still negative.

DISCUSSION.—Since no parathion, free *p*-nitrophenol, or free *p*-aminophenol ever was found in the milk, blood, or urine of the cows fed parathion, the fate of the insecticide in the animals' bodies was investigated. Good evidence was obtained to support the contention that parathion might be hydrolyzed enzymatically *in vivo* to *p*-nitrophenol. It is interesting to note that the personnel of two other laboratories working independently on this same problem with other experimental animals (Mountain *et al.* 1951; Gardocki and Hazleton[1]) also have concluded that parathion is detoxified in the mammalian body to *p*-nitrophenol. No serious discrepancies exist between our work and that reported by others working on this problem. Mountain *et al.* (1951) apparently found free *p*-nitrophenol in the urine but did not state the animal with which they worked. Although Gardocki and Hazleton state that parathion is hydrolyzed to *p*-nitrophenol, their procedure includes an acid hydrolysis before the reduction step, indicating they too might have been dealing with conjugated *p*-nitrophenol and *p*-aminophenol. Thus, earlier speculation as to the fate of parathion in the animals' bodies has been replaced by experimental evidence that seems to explain why sublethal doses of parathion are not stored in the vital organs or body fat of the animal as is the case with several of the other new synthetic organic insecticides.

Ketelaar (1950) and Ketelaar and Hellingman (1951) in their chemical studies on the purity of parathion have suggested that a small amount of unreacted *p*-nitrophenol might be present in technical parathion. Although we have no data on the amount of *p*-nitrophenol that might have been present in the 25 per cent parathion wettable powder we fed in capsules, we did determine by the Averell and Norris (1948) method that approximately 24 per cent of the 25 per cent was parathion, and, therefore, the *p*-aminophenol detected in the urine must have resulted largely from the parathion itself.

Evidence of the fate of the thiophosphoric acid portion of the parathion molecule is not available. Recent studies employing radio-active parathion containing phosphorous-32 have been designed to answer this question.

The various parathion studies conducted at this station on the dairy cow over a period of almost three years have shown consistently the absence of either parathion or its degradation and detoxication products in the cows' milk. Therefore, the safety of this insecticide from a food residue standpoint would appear to have been firmly established. The operational hazards and necessary safety precautions involved in the field application of parathion to crops have obviously not been included in these studies.

The implications of these feeding experiments involving excessive intake of the insecticide seem to indicate clearly and conclusively that forage crops sprayed with parathion at the usual rates for insecticidal purposes are not made unsafe for livestock feed. It should be emphasized also that in all our experimental feeding of parathion to dairy cows, no measurable effects on milk production, weight, and general health of the cows ever were observed.

SUMMARY AND CONCLUSIONS.—Parathion, in the form of an excessively heavy experimental residue of approximately 14 parts per million on baled alfalfa hay, was fed over a 61-day period to five dairy cows in mid-lactation and representing four of the major breeds. The average parathion intake for all cows during the experimental period was 166.9 milligrams of parathion per cow per day or 0.33 milligram of parathion per kilogram of cow body weight per day. Neither parathion nor free *p*-nitrophenol, a probable hydrolytic product of parathion, ever was found in the milk or jugular blood of these experimental animals. The feeding of parathion as a forage residue at this rate had no adverse effects on the milk production, weight, and general health of the cows.

The degradation and detoxication of parathion was studied further in a second series of experiments in which parathion, as a commercial wettable powder, was fed in capsules at increasing rates of from one to 32 milligrams of parathion per

[1] Mimeographed procedure from Joseph F. Gardocki and Lloyd W. Hazleton, Hazleton Laboratories, Falls Church, Virginia, U.S.A.

kilogram of cow body weight per day. No parathion, free *p*-nitrophenol, or free *p*-aminophenol ever was found in samples of jugular blood, urine, and milk taken during the experimental period. Experimental evidence indicates that the parathion must be hydrolyzed *in vivo* to *p*-nitrophenol, reduced to *p*-aminophenol, conjugated with glucuronic acid to an appreciable extent and then excreted in the urine as *p*-aminophenylglucuronide. The fate of the thiophosphoric acid portion of the parathion molecule was not determined.

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Mite Control with Concentrated Acaricides[1]

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Two experiments to compare the effectiveness of certain acaricides in concentrated spray schedules were conducted in Adams County during the 1951 season.

MOUNTAIN TOP ORCHARD.—In this orchard, owned by the C. H. Musselman Co., a block of mature Stayman Winesap trees was divided into 10 plots. Basically, the plots were four trees long by four trees wide. Since the block is irregular in shape, however, some plots were more than four trees long. Three trees at the apex of a triangular section of the block were marked 0 and received no acaricidal sprays.

The various acaricidal treatments in this test are listed in table 1 and the symbols used for trade name and experimental products will be found in the footnotes to this table. A dormant spray of oil and DN paste was applied only to plots 1 and 2. The delayed dormant treatment on these two plots was oil and bordeaux mixture, on all the other plots 70 per cent sulfur paste at the rate of 22 pounds in 100 gallons. During the rest of the season, all plots received the same fungicidal treatments with the exception of the fifth cover on plot 2 (Table 1). In terms of 100 gallons of spray, the fungicides were used as follows: pre-pink—22 pounds of 70 per cent sulfur paste; pink, full bloom, petal fall and first cover—11 pounds of 70 per cent sulfur paste plus 3 pounds of 76 per cent ferbam; second, third, fourth and fifth covers—3 pounds of 76 per cent ferbam (see plot 2, table 1 for exception).

The plots were also sprayed with certain standard insecticides in addition to the fungicides and acaricides. Except for plots 1 and 2 which had been treated with DN paste in dormant, all the plots were sprayed in pre-pink with 6 pounds of benzene hexachloride (6 per cent gamma isomer) in 100 gallons to control aphids. In petal fall and first cover, parathion was the only insecticide applied to plots 9 and 10 (Table 1), but the other plots received lead arsenate at the rate of 9 lbs. in 100 gallons in petal fall and 12 lbs. in first cover.

The second, third and fourth cover sprays on plots 9 and 10 included 9 pounds of lead arsenate in 100 gallons and the fifth cover spray contained 3 pounds of 50 per cent DDT. In the second, third, fourth and fifth cover sprays, plots 1 through 8 received 6 pounds of 50 per cent DDT. On August 25, all plots were sprayed with 4 pounds of 50 per cent TDE as a treatment for red-banded leafrollers. The dates of applications were: dormant March 21; delayed dormant April 12; pre-pink April 21; pink April 27; full

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[3] Technical assistant during 1951 growing season.

bloom May 10; petal fall May 16; first cover May 23; second cover June 4; third cover June 18; fourth cover July 2; fifth cover Aug. 2; and special leafroller spray Aug. 25.

It will be noted that in most cases the pesticides were used at concentrations considered three times standard (3×) under Pennsylvania conditions. All sprays except the dormant[1] spray on plots 1 and 2 were applied with a 1951 model sprayer[2] with the fan turning at the rate of 2175 RPM. In spraying plots 1 through 9, the low pressure pump, standard equipment on the machine, was used to deliver spray into the air stream through whirljet nozzles. Pressure at the nozzles was 83 PSI (pounds per square inch). For plot 10, beginning with the petal fall spray, a special high pressure pump was employed with another bank of smaller whirljet nozzles through which spray was delivered into the air stream at 200 PSI.

The sprayer was operated with one side open, the shield on the off-side being closed to deflect the maximum amount of air to the open side. The sprayer was driven at 2.5 m.p.h. in plots 1 to 9. For the prebloom sprays, nozzles were selected to apply about 3 gallons per tree as a complete spray on both sides of the trees; for petal fall through third cover, 3.5 gallons per tree; and for fourth and fifth covers, 4 gallons per tree. Since only a few nozzles were available for the high pressure system, the gallons per tree applied to plot 10 were regulated to approximate the applications in the other plots by varying the ground speed of the machine. Dilute sprays on these same trees would have ranged from 15 to 20 gallons each as the season progressed.

The mite counts reported in table 1 were taken from the same two trees in the center of each plot throughout the season. The counts represent 100 leaves, 50 leaves from the inside[3] of each tree running from top to bottom. The majority of the leaves were from spurs, but for some counts a few leaves from suckers and terminals growing on the inside were included. For each count, an attempt was made to keep the collections of leaves similar. For example, if two men did the collecting, one gathered from one tree and one from the other in each plot.

In making the collections of leaves for a count, four trips were made to the field. After each collection, the leaves were brought to the laboratory immediately and the mites were brushed onto varnish-coated glass plates and counted. The first four counts were completed in 1 day each, but 2 days were required for the last two counts because foggy mornings made the leaves too wet to handle early in the day.

All motile forms of the mites and mite eggs were counted. The egg counts are not reported because they follow closely the pattern of the counts of motile forms. The mite population included European red mites, schoenei mites and two-spotted mites. European red mites made up about 25 per cent of the population in July. During August this species almost disappeared from the trees, but in early September they reappeared and started to lay winter eggs. By mid-September the other two species had started to seek winter quarters, and no more counts could be made of mites taken from leaves.

It will be noted in table 1 that some of the plots received split acaricidal treatments. Since the details regarding all the treatments are presented in table 1, the treatments will be referred to by plot number in the following discussion.

The mite population in plot 0, check, failed to show an increase over the previous count on only one date, Aug. 9. It is possible that plot 0 received a small amount of drift from the application to adjacent plots on Aug. 2. It will be noted, however, that the mite population in plot 0 was still increasing at the time of the last count in September.

From the data in table 1, it is obvious that the treatments applied to plots 9, 10 and 6 controlled mites better throughout the season than did the other treatments. At the end of the season, the foliage in these plots showed only a slight trace of bronzing. The fruit from these plots was, however, considerably more russeted[4] than the fruit from plots 5 and 2.

Actually, plots 9 and 10, which were sprayed 6 times with the same acaricide, parathion, were set up as a special com-

[1] Applied with a *Model JXD* Speed Sprayer equipped with *Teejet* nozzles. Sprayer borrowed from the C. H. Musselman Co.

[2] Manufactured by the John Bean Division of the Food Machinery and Chemical Corporation. (Model 36Z)

[3] The term "inside the tree" as used in this paper means that portion of the tree within a radius of 5 feet from the trunk beginning with the limbs nearest the ground and running to the accessible top of the tree.

[4] A detailed discussion of the influence of pesticides on fruit finish will be presented at a future date in a report of a study of this problem in cooperation with Dr. F. H. Lewis, plant pathologist at Arendtsville.

Table 1.—Results of concentrated acaricidal treatments in the Mountain Top Orchard.

Plot	Date Spd.	Acaricides in 100 Gal.		Mites Per Leaf 6/22	7/9	7/26	8/9	8/20 & 21	9/7 & 8
1	3/21	97.5% Oil[1]	3 gal.						
		DN Paste[2]	3 pts.	0.24	2.88	23.20	17.92	14.24	27.20
	4/12	Copper sulphate	3 lb.						
		Lime	3 lb.						
		97.5% Oil[1]	3 gal.						
	7/2	Parathion[3]	36 oz.						
		Carbon[4]	36 oz.						
	8/2	TM-88R[5]	6 lb.						
		Ferbam	3 lb.						
2	3/21	Same as plot 1		0.08	2.56	28.08	18.96	16.40	18.80
	4/12	Same as plot 1							
	7/2	Same as plot 1							
	8/2	TM-88R[5]	6 lb.						
		Copper sulphate	3 lb.						
		Lime	9 lb.						
3	5/16	Parathion[3]	24 oz.	0.80	3.68	27.12	9.20	20.96	126.80
	5/23	Carbon[4]	24 oz.						
	7/2	Parathion[3]	36 oz.						
	8/2	Carbon[4]	36 oz.						
4	5/16	TM-88R[5]	3 lb.						
	5/23	TM-88R[5]	3 lb.						
	7/2	TM-88R[5]	6 lb.	0.48	6.64	34.08	12.24	3.68	21.44
	8/2	TM-88R[5]	6 lb.						
5	5/16	Parathion[3]	24 oz.	1.20	6.96	40.64	8.32	3.20	26.56
	5/23	Carbon[4]	24 oz.						
	7/2	TM-88R[5]	6 lb.						
	8/2	TM-88R[5]	6 lb.						
6	5/16	TM-300[6]	24 oz.	0.16	0.48	4.88	2.24	5.36	43.28
	5/23	Carbon[4]	24 oz.						
	7/2								
	8/2								
7	5/16	Parathion[3]	24 oz.	0.40	2.88	28.72	14.32	3.04	29.08
	5/23	Carbon[4]	24 oz.						
	7/2	TM-242[7]	6 lb.						
	8/2	TM-242[7]	6 lb.						
8	5/16	TM-24[8]	24 fl. oz.	0.16	2.64	39.44	10.96	9.28	19.20
	5/23	TM-24[8]	24 fl. oz.						
	7/2	TM-24[8]	24 fl. oz.						
	8/2	TM-24[8]	24 fl. oz.						
9	5/16	Parathion[3]	3 lb.	0.00	0.16	0.72	0.32	1.52	27.60
	5/23	Carbon[4]	3 lb.						
	6/4								
	6/18	Parathion[3]	36 oz.						
	7/2	Carbon[4]	36 oz.						
	8/2								
10		Same as plot 9		0.00	0.16	2.48	4.72	7.84	23.20
0		No Acaricides		4.96	20.48	40.72	34.40	72.08	131.98

[1] 97.5% Oil—Superior Nu-Oil supplied by Miller Chemical and Fertilizer Corp.
[2] DN Paste—Krenite, sodium salt of dinitro ortho cresol (19%), manufactured by E. I DuPont de Nemours & Co.
[3] Pth—Thiophos WP, parathion (15%), supplied by American Cyanamid Co.
[4] Carbon—Nuchar C-115N, activated carbon, supplied by West Virginia Pulp and Paper Co.
[5] TM-88R—Aramite 15-W, beta-chloroethyl beta-(p-tertiarybutylphenoxy)-alpha methyl ethyl sulfite (15%), supplied by Naugatuck Chemical.
[6] TM-300—EPN 300, ethyl p-nitrophenyl thionobenzenephosphonate (27%), supplied by E. I. DuPont de Nemours & Co.
[7] TM-242—Sulphenone WP, p-chlorophenyl sulfone (25%) and related aromatic sulfones (15%), supplied by Stauffer Chemical Co.
[8] TM-24—Metacide Emulsion, parathion (6.2%), o, o-dimethyl o-p-nitrophenyl thiophosphate (24.5%) and related organic phosphates (2.7%), supplied by Dow Chemical Co.

parison and should be so considered. The special pump, and nozzles used in spraying plot 10 were the only differences involved in treating these two plots. Two factors were probably responsible for the excellent control of mites in plots 9 and 10. The six applications of parathion prevented the mites from starting to increase significantly in numbers until the end of the season. Also, plots 9 and 10 received only 1 half-strength spray of DDT during the season.

Plot 6 and all the other plots except 9 and 10 were sprayed only four times with acaricidal treatments. Plot 6 was sprayed with the same acaricide, TM-300, all four

times and it was applied at a concentration strong enough to take advantage of the residual powers inherent in the active ingredient, a fact that propably accounts for the high degree of control in this plot.

There are several points worth considering in connection with the data in table 1 in addition to total control of mites for the season. By the time of the first mite count on June 22, plots 1 and 2 had been sprayed with no other acaricide than petroleum oil in dormant and delayed dormant; plots 3 through 8 had received acaricidal treatments in only the petal fall and first cover sprays; and plots 9 and 10 had been sprayed 4 times with an acaricide. Yet, except for the absence of mites in plots 9 and 10, the differences between the numbers of mites in the plots on June 22, a month after the first cover spray, cannot be considered great. In other words, the mite count of June 22 indicates that petal fall and first cover sprays of effective acaricides may be substituted for dormant and delayed dormant sprays to control mites early in the season.

Plots 3, 5 and 7 received the same acaricide, parathion, in petal fall and first cover. Plot 3 continued to be sprayed with parathion in fourth and fifth covers, but plot 5 received TM-88R and plot 7 TM-242. The control of mites in plots 5 and 7 was definitely better than in plot 3 during the last 4 weeks of the season. The foliage in plots 5 and 7 was a little more bronzed than the foliage in plots 6, 9 and 10, but it was distinctly better than average at the end of the season. The apples in plot 5 showed less russeting than apples in any other plot in the test. On the other hand, the apples in plot 7 ranked with those in plots 6, 9 and 10.

Plot 4 was treated with TM-88R, a residual type compound, at the rate of 3 pounds per 100 gallons in petal fall and first cover and 6 pound in fourth and fifth covers. The data in table 1 show that the lower concentration did not hold mites so well as did TM-300 in plot 6, but the higher concentration did as well as or better than, TM-300 during the later part of the season. The apples in plots 4 and 3 had much more russet than the apples in plot 5, a fact which indicates that both TM-88R and parathion may be more satisfactory in split schedules than in full schedules of sprays on Stayman Winesaps.

The residual powers of TM-88R at the 6 pound concentration are also demonstrated in a comparison of the last two mite counts for plots 1 and 2 and plot 3. The July 2 spray on all these plots was the same. On Aug. 2, both plots 1 and 2 were sprayed with the 6 pound concentrations of TM-88R. For plot 1 it was combined with ferbam and DDT and for plot 2 with bordeaux mixture and DDT. Plot 3 was sprayed with parathion, ferbam and DDT.

Table 2.—Results of concentrated acaricidal treatments in the McDannell orchard.

Plot	Date Spd.	Acaricides in 100 Gal.	Mites per Leaf 6/22	7/6	7/16	7/28	8/3	8/17	8/29	9/19
1	6/26	TM-1014[1] 24 fl. oz.	11.20	9.68	4.40	5.12	4.64	5.52	26.32	45.76*
	7/10	TM-1014[1] 24 fl. oz.			2.72*				20.16*	
	7/30	TM-1014[1] 1 pt.								
2	6/26	TM-923[2] 24 fl. oz.	8.08	18.64	44.96	25.76	20.08	56.16	56.00	52.32*
	7/10	TM-923[2] 24 fl. oz.			7.60*				46.32*	
	7/30	TM-923[2] 3 pt.								
3	6/26	TM-4049[3] Emul. 3 pt.	9.44	1.28	0.80	2.72	0.56	2.16	14.96	29.60*
	7/10	TM-4049[3] Emul. 3 pt.			0.16*				10.00*	
	7/30	TM-4049[3] WP 6 lb.								
4	6/26	TM-1006[4] 3 lb.	11.52	4.64	8.50	1.20	2.56	3.28	7.52	19.68*
	7/10	TM-1006[4] 3 lb.			2.16*				5.92*	
	7/30	TM-1006[4] 3 lb.								
5	6/26	TM-88E[5] 24 fl. oz.	11.52	11.92	2.00	0.40	0.72	0.32	0.64	8.32*
	7/10	TM-88E[5] 24 fl. oz.			0.56*				1.12	
	7/30	TM-88E[5] 24 fl. oz.								
6	6/26	TM-88R[6] 4.5 lb.	12.96	10.24	5.28	1.44	1.12	0.96	2.64	6.96*
	7/10	TM-88R[6] 6 lb.			0.96*				1.76*	
	7/30	TM-88R[6] 6 lb.								
7		No Acaricides	15.84	10.88	35.68	15.36	23.92	89.84	64.24	44.48*
					10.80*				33.84*	

[1] TM-1004—Octa-methylpyrophosphoramide (63.3%) supplied by Dow Chemical Co.
[2] TM-923—Genite 923 Emulsion, 2,4-dichlorophenylbenzene sulfonate (50%), supplied by General Chemical Co.
[3] TM-4049—S-(1,2-Dicarbethoxyethyl) 0,0-dimethyl dithiophosphate (50.3% emulsion and 25% WP), supplied by American Cyanamid Co.
[4] TM-1006—P-chlorophenyl p-chlorobenzene sulfonate (50% WP), supplied by Dow Chemical Co.
[5] TM-88E—Aramite Emulsion, beta-chloroethyl beta-(p-tertiarybutylphenoxy)-alpha methyl ethyl sulfite (4.8 pounds per gallon), supplied by Naugatuck Chemical.
[6] TM-88R—Aramite 15-W, beta-chloroethyl beta-(p-tertiarybutylphenoxy)-alpha methyl ethyl sulfite (15% WP), supplied by Naugatuck Chemical.
* Samples from periphery of trees.

On Aug. 9, 1 week after this spray, plot 3 had fewer mites than the other two plots. But from then to the last of the season the control of mites in plots 1 and 2 was better. There was less russet on the apples in plot 2 than in plots 1 and 3, but the difference in fungicides undoubtedly was a factor that should be considered in connection with russeting.

The treatment in plot 8 has not been discussed along with the others because it reduced the vigor of the trees and caused severe russeting of the fruit. As an acaricide it performed reasonably well, however, and merits further study.

Of the other observations in the plots in this experiment, the following yielded information of interest. Aphids were numerous on apple trees in southern Pennsylvania in the spring of 1951. Green apple aphids predominated, but the population included some rosy apple aphids. In this experiment, an examination of buds on April 13 showed 0.5 per cent of the buds infested in plots 1 and 2 which had received a dormant spray of oil and DN paste as compared to 65.5 per cent infested buds in adjacent plots that had not been treated with an aphicide. Six days after the latter plots were sprayed with benzene hexachloride only 0.5 per cent of the buds remained infested.

On Aug. 8, 50 suckers were collected from two trees in each plot and examined for colonies of woolly apple aphids. Plot 8, with 38 colonies on 100 suckers, was the only plot with a light infestation.

EDGAR C. MCDANNELL FARM.—On this farm, located on the edge of Arendtsville, a block of 27 year old York Imperials had been divided into seven 4 by 4 plots for an early season experiment which was discontinued. After making a count of mites on June 22 before any summer sprays of acaricides had been applied to this block, it was decided that the mite population was homogeneous enough throughout the block to use for a further study of acaricides in concentrated sprays.

Prior to the June 22 mite count, this block of trees had been concentrate sprayed with two applications of DDT and ferbam and one application of TDE emulsion. On June 26, the acaricides listed in table 2 were combined with DDT and ferbam. The acaricides were used alone in the July 10 spray and were again combined with DDT and ferbam on July 30. The sprays on June 26 and July 10 were applied with a Bean 17 Mist Applicator[1] and the spray of July 30 with an Iron Age Orchard Mist Machine[2]. All sprayers were operated on one side and at full capacity. The nozzles were adjusted to deliver 4 gallons per tree for a complete spray at a forward speed of 2 m.p.h.

The whole block of trees was sprayed lightly with DDT on July 20 to control Japanese beetles. On July 26, the sucker zone of all the trees was pressure sprayed with TDE emulsion to control leafrollers. and the whole block was concentrate sprayed with this insecticide on Aug. 24.

Sampling of leaves for mite counts was handled in the same manner as in the Mountain Top Orchard. In table 2, it will be noted that on July 16 and Aug. 29 counts were run on leaves collected from both the inside and the outside of the trees And the final count on Sept. 17 was from a collection of outside leaves. Study of the mite counts from inside and outside leaves will support the hypothesis that in an apple tree the build-up of a mite population starts on the inside of the tree. This hypothesis is the reason for choosing inside leaves for most of the mite counts.

In the McDannell block, European red mites, schoenei mites and two-spotted mites were present in about the same proportions of the population as in the Mountain Top Orchard.

One difference between the two tests to remember in considering the data is that the same acaricidal compound was used in all the mite sprays in a given plot in the McDannell block.

The general slump in the mite population at MacDannell's revealed by the July 28 count may be attributed to the spray of the TDE emulsion applied to the suckers of all the trees of July 26. As the counts for plot 7, the check plot, indicate, the population of mites continued to increase after July 28 and the natural decline did not occur until late August.

The counts in table 2 show that the first application of TM-4049 to plot 3 reduced the original mite population more quickly than did the first application of the other acaricides. However, TM-88E and TM-88R as used in plots 5 and 6 respectively ranked first in residual toxicity to mites and were followed by TM-1006 in plot 4, TM-4049 in plot 3, TM-

[1] Manufactured by the John Bean Division of the Food Machinery and Chemical Corp.
[2] Supplied by A. B. Farquhar Co.

1014 in plot 1 and TM-923 in plot 2 in the order listed. Only TM-923 failed to give commercially satisfactory control of mites in this test. The other treatments held the mites in check long enough to prevent serious injury to the foliage.

An examination of 100 suckers per plot on July 17 for woolly apple aphid colonies indicated that TM-4049 in plot 3 was the only treatment that had prevented a build-up of this pest.

None of the treatments used in the McDannell block caused observable chemical injury to the York Imperial trees.

SUMMARY AND CONCLUSIONS.—In two experiments, petroleum oil and 12 acaricidal preparations were tested in concentrate spray schedules in a total of 16 treatments. In each spray, the pesticides were used at three times (3×) the concentration that would have been used in a dilute spray for the same purpose at that season in southern Pennsylvania.

The first experiment in a block of mature Stayman Winesap trees included 10 acaricidal treatments. Two plots, 9 and 10 table 1, were sprayed with the same spray mixtures. These included 6 containing parathion, but a high pressure pump arrangment on the speed sprayer was employed in plot 10 and the standard low pressure pump was used in plot 9. Although the mite control data in table 1 show that mites started to increase in numbers a little earlier in the season in plot 10 than in plot 9, there is not a great enough difference to justify a decision in favor of either system of spraying. Both treatments gave excellent control of mites in a population including european mites, schoenei mites and two-spotted mites.

Petroleum oil in the dormant and delayed dormant sprays followed by summer applications of acaricides in the fourth and fifth cover sprays was no more effective than acaricides applied in the petal fall, first, fourth and fifth cover sprays.

Four sprays of parathion (plot 3) were not so effective in controlling a mixed population of mites as petal fall and first cover sprays of parathion followed by fourth and fifth cover sprays of either TM-88R (plot 5) or TM-242 (plot 7).

TM-300, plot 6, at the rate of 1.5 pounds per 100 gallons in four sprays gave the best control of mites throughout the season. However, residual control was somewhat better with TM-88R after it had been used at 6 pounds in 100 gallons as in fifth cover in plots 1 and 2 and in fourth and fifth covers in plots 4 and 5.

TM-88R with bordeaux in fifth cover, plot 2, was no less effective than a TM-88R and ferbam mixture in plot 1. In fact, the September count of mites is in favor of the mixture involving bordeaux.

Parathion in petal fall and first cover followed by TM-88R in fourth and fifth covers (plot 5) caused less russeting on the fruit than the other treatments. Apples from plot 2, which received another split treatment ending with TM-88R and bordeaux mixture in fifth cover, ranked next. Yet apples sprayed four times with TM-88R were badly russeted. Parathion, on the other hand, russeted apples more severely where it was used in both early and late season sprays than where it was used in early season only. This information regarding the effect of TM-88R and parathion on apple russet probably means that in the split schedules the type of injury to the skin of Stayman apples caused by either acaricide was held to a minimum and does not necessarily indicate the times at which all the injury was caused in the full schedules.

Green apple aphids and rosy apple aphids were effectively controlled by either the combination of oil and DN paste in dormant or by BHC in prepink.

In the second experiment, five acaricidal compounds were tested in a series of six treatments in a block of York Imperial apple trees. In one case, plot 3, the type of formulation was changed, but in each plot the same acaricidal compound was used in all three mite control sprays. As mentioned in the body of the paper, two concentrate sprayers were employed in this experiment.

As a residual acaricide, the active compound in TM-88E (plot 5) and TM-88R (plot 6) ranked first in this series followed by TM-1006 (plot 4), TM-4049 (plot 3), TM-1014 (plot 1) and TM-923 (plot 2) in the order listed. TM-4049 was quicker in action against mites than the other acaricides in this test.

Counts of mites from collections of leaves on the inside and the outside of the trees support the hypothesis that the build-up of a mite population starts on the inside of an apple tree.

Of the test materials in both experiments, only TM-24 and TM-4049 prevented a build-up of woolly apple aphids.

Continuous Rearing of the Codling Moth[1]

R. C. Dickson,[2] M. M. Barnes,[2] and C. L. Turzan,[3,4] *University of California Citrus Experiment Station, Riverside*

Until recently, no method for the continuous rearing of the codling moth, *Carpocapsa pomonella* (L.), in the laboratory has been available. The rearing procedure described in this paper has proved satisfactory over a number of years and will provide a supply of all stages of the moth at all seasons. It also makes possible the maintenance of lines for use in studies concerning the possible existence or development of strains resistant to insecticides. A constant supply of codling moth in all stages is valuable for insecticide screening, physiological studies, or parasite rearing.

The method chiefly in use in the past for providing laboratory material of codling moth was based upon field collection and cold storage of mature larvae (Farrar & Flint 1930). This method involved a considerable amount of time and labor in scraping and banding trees. It was also usually necessary to break the diapause of the collected larvae, either by a long period of storage or by forced respinning. The supply was not continuous and did not provide an unbroken succession of generations. Theron (1947) succeeded in rearing codling moth on a medium based on corn meal, but did not obtain satisfactory yields and did not overcome the diapause problem. Dickson (1949) solved this latter problem by determining the role of photoperiod in diapause.

Any of the methods used previously to supply codling moths for laboratory use are satisfactory for setting up the stock. Moths are usually reared from larvae spun up in bands placed on tree trunks. Field-collected material frequently contains some parasites and predators, but these are easily eliminated. Infestations of the stock by *Pediculoides* sp. may be readily controlled by light application of dusting sulfur.

Collection of Moths.—Moths are collected in the laboratory by a convenient type of suction device. This device[5] consists of a metal tube 1.25 inches in diameter, connected by 1.25-inch Gooch crucible tubing to the vacuum source. The moths are collected in a test tube 1 inch in diameter, the closed end of which has been cut off and replaced by brass wire screen. The open end is fitted with a rubber stopper through which a 9-mm. O. D. glass tube is inserted. The test tube slips inside the metal tube and is held tightly by the rubber crucible tubing. Moths are readily collected without injury by the use of this apparatus, and may be transferred quickly from it to one of the cages used for oviposition.

Oviposition.—The moths oviposit on the waxed-paper liner of the celluloid oviposition cage (Fig. 1). These cages, which are 6 inches in diameter and 11 inches long, are fitted at each end with a removable celluloid cap having a wire screen center. The waxed paper used for liners is

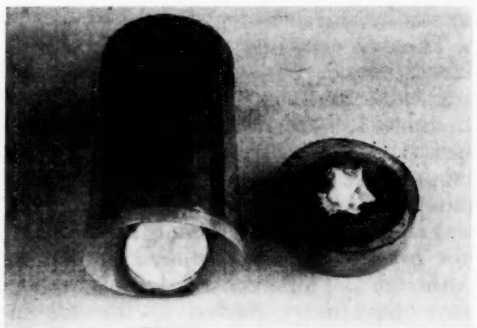

Fig. 1.—Celluloid oviposition cage with waxed-paper liner, watering dish, and plugged cap.

12 inches wide, and 0.5 inch of the paper is folded back outside the celluloid cylinder at each end, so that the liners are held in place by the caps. A pad of wet cotton enclosed in cheesecloth is placed in a dish in each cage to provide water for the moths.

Moths oviposit best when exposed to natural twilight. We have never obtained equally satisfactory oviposition under artificial light. Measurement of light intensities at twilight has shown that light of decreasing intensity, below 50 foot-

[1] Paper No. 706, University of California Citrus Experiment Station, Riverside, California.

[2] Assistant Entomologist in the Experiment Station.

[3] Senior Laboratory Technician in the Experiment Station.

[4] The method of codling moth rearing described was developed over a period of several years with material assistance from a number of people who have been associated with the project. The writers are especially indebted to Earl Sanders, J. B. Shanafelt, Frank Summers, Louise Ratcliff, Glenn Carman, Blair Bartlett, and Metta McD. Johnson for their original contributions to the method.

[5] Designed by Dr. Blair R. Bartlett of the University of California Citrus Experiment Station.

candles, stimulates oviposition. Attempts to reproduce this light of decreasing intensity in the laboratory by the use of a rheostat have not given as satisfactory egg production. Light of increasing intensity, such as natural morning light, stimulates very little activity on the part of the moths, even though the temperature is favorable. Evening light from a west window or in a greenhouse has been quite satisfactory. The egg sheets may be changed each day, although changing them at less frequent intervals gives higher production.

Small numbers of moths will oviposit in one of these cages, but higher egg yields per moth are obtained when each cage contains about 100 moths (Sazama 1932). The number of eggs produced varies, particularly with the season, and is generally poorer in the winter than in the summer. The production of 20 eggs per female is considered good, although batches of moths will sometimes average better than that.

REARING THE LARVAE.—The larvae are reared in apple thinnings. These small green apples, 1 to 1.5 inches in diameter, are obtained from growers at thinning time and stored up to a full year at regular apple-storage temperature (32° F.) until needed. Certain apple varieties are more satisfactory than others for rearing larvae because they keep better in storage and are less subject to breakdown after withdrawal. Locally, Winesap and Rome Beauty have been preferred to Delicious, Golden Delicious, or White Pearmain.

A rearing tray of the kind currently in use is shown in figure 2. These are made of galvanized iron and are 12 inches wide, 13 inches long, and 4 inches deep, and are painted white. Tops consist of metal frames holding 28-mesh brass strainer cloth. The edges of the tops are lined with felt to prevent the larvae from escaping. Two of these trays fit into the glass-topped sleeve cages used for moth emergence.

Other types of rearing trays have been used, notably wooden trays with removable cloth tops.

The metal trays are lined with waxed paper and about 130 apple thinnings are laid in each. Some 600 eggs, on pieces of waxed paper, are placed in each tray, and the tray is covered and put in a glass-topped sleeve cage. The rearing room is

FIG. 2.—Metal rearing tray containing apple thinnings, codling moth eggs on waxed paper, and corrugated cardboard partitions for pupation.

held at a temperature of 84° F. and at a relative humidity of about 35 per cent. At this temperature larval feeding is completed in about 18 days. The mature larvae spin cocoons in strips of corrugated paper which surround and form partitions among the apples. After larval spinning is complete, the tops are removed from the trays so that the moths may emerge into the surrounding sleeve cage. The duration of the cycle from moth to moth is about 28 days.

The light in the room during larval feeding is of the utmost importance. Unless the photoperiod is controlled, the larvae may enter diapause. As shown by Dickson (1949), codling moth larvae exposed to 15 or more hours of light per day while feeding do not enter diapause. To prevent diapause, all daylight is excluded from the rearing room and tungsten-filament lights are kept burning 24 hours per day. Illumination at the surface of the apples is about 3 foot-candles. It would be just as effective to burn the lights 15 or 18 or some similar number of hours per day. By inference from studies with the oriental fruit moth, *Grapholitha molesta* (Busck) (Dickson 1949), it should be possible to prevent diapause by rearing the larvae in total darkness.

PRODUCTION.—Yields from this rearing procedure have averaged about 60 moths per tray of 130 apples and 600 eggs. Viability of eggs averages about 60 per cent. Higher humidity during egg hatching gives more hatches and more entries but predisposes to loss of fruit from fungus decay, with resultant lower yields. With two to four trays, this production of 60 moths per tray provides an ample supply of eggs for colony maintenance of eggs

and other developmental stages for insecticide work or biological investigations. Additional trays would be required to provide a constant supply of all stages.

This method is also used in rearing the oriental fruit moth, except that it is desirable to perforate the skin of the apple thinnings to increase larval entries. This species is much easier to rear than the codling moth, chiefly because the moths oviposit more readily and the larvae are not cannibalistic.

SUMMARY.—A method for rearing the codling moth, *Carpocapsa pomonella* (L.), continuously in the laboratory has been developed. This method has proved satisfactory over a period of years and can provide a constant supply of all stages of the moth at all seasons.

The moths oviposit on waxed-paper liners of cylindrical celluloid cages. Apple thinnings are kept in cold storage until needed and are then placed in trays and infested with codling moth eggs. Diapause is prevented by exposing the feeding larvae to constant illumination. Mature larvae spin up in corrugated paper strips. Moths emerge into the surrounding sleeve cage.

Essentially the same method is used in rearing the oriental fruit moth, *Grapholitha molesta* (Busck).

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A Cooperative Test to Evaluate Methoxychlor for Control of Plum Curculio on Apples

W. D. WHITCOMB[1]

One of the most persistent insect pests in New England and eastern New York is the plum curculio which, in this area, attacks apples equally or more than peaches. During recent years the failure of the recommended pesticides to give the degree of control demanded by commercial apple growers has stimulated the study of the newer insecticides for this purpose.

A plan for a large scale cooperative test with identical insecticides and relatively uniform procedure was submitted in November, 1950, to the 12th Annual Conference of the New England-Hudson Valley Fruit Specialists, a group of research and extension workers studying fruit growing problems in the area. Workers in eight locations in six states agreed to cooperate with the writer as coordinator. This report was prepared in cooperation with the participants who are listed in the first footnote. The area in which the tests were made was approximately 250 miles in diameter extending from Poughkeepsie, N. Y. to Durham, New Hampshire, and from Bennington, Vermont to Kingston, Rhode Island.

Preliminary tests in the area had shown methoxychlor either alone or in combination with lead arsenate to be a very promising insecticide to control the plum curculio in apples and these materials were selected for the cooperative test. The methoxychlor[2] and the lead arsenate were supplied by the manufacturer from the same batch or lot and furnished on direct order to each cooperator.

EQUIPMENT.—Most of the applications were made with hydraulic spray machines at 400 pounds pressure or more, and each cooperator reported that uniform coverage

[1] Cooperators: A. I. Bourne, Massachusetts Agricultural Experiment Station, Amherst; C. L. Calahan, University of Vermont, Burlington; J. G. Conklin, New Hampshire Agricultural Experiment Station, Durham; R. W. Dean, New York Agricultural Experiment Station Fruit Laboratories, Poughkeepsie; Philip Garman, Connecticut Agricultural Experiment Station, New Haven; T. W. Kerr, Rhode Island Agricultural Experiment Station, Kingston (Joint Cooperator); M. C. Shurtleff, Rhode Island Agricultural Experiment Station, Kingston (Joint Cooperator); R. H. Sudds, Connecticut Agricultural Experiment Stations, Storrs; W. D. Whitcomb, Massachusetts Agricultural Experiment Station Field Station, Waltham.

[2] Marlate; furnished by E. I. DuPont de Nemours & Co., Grasselli Chemicals Department, through the courtesy of Dr. Harry F. Dietz.

was secured. Most of the operators used spray guns but included in the tests were a "*Speed Sprayer*," two types of stationary booms and a 9-nozzle oscillating head machine.

TIME OF APPLICATION.—In New England, the period of greatest curculio activity normally begins at the petal-fall stage of McIntosh apples and continues for about 3 weeks, and the calyx spray is the first application recommended to combat this pest. It has also been shown that high temperature stimulates beetle activity rapidly and that adequate protection is necessary when the thermometer reaches 75° F.[1] if the young fruits are at least one-quarter inch in diameter.

With these factors in mind, each cooperator determined the time of application of the special curculio sprays (first and second cover sprays) in his locality.

In these tests the calyx spray was applied in five of the eight localities in the 2-day period May 16–17. In New Haven, Connecticut, the earliest area, it was made May 14 and on May 22–23 in New Hampshire and Vermont, the latest areas.

The timing of the first cover spray was also surprisingly uniform. It was made May 22–25 in New York, Massachusetts, Rhode Island, and Connecticut; while in Vermont and New Hampshire the dates were May 27–28.

A similar interval was maintained for the second cover spray, with the orchards in the central area being teated May 28-June 1, and in the northern area June 4–6.

Table 1.—Date of application.

	CALYX	1ST COVER	2ND COVER
Connecticut, New Haven	May 14	—	May 29
Massachusetts, Waltham	May 16	May 22	May 28
Massachusetts, Amherst	May 17	May 23	May 31
Connecticut, Storrs	May 17	May 23	May 31
New York, Poughkeepsie	May 17	May 24	June 1
Rhode Island, Kingston	May 17	May 25	May 31
Vermont, Bennington	May 23	May 27	June 4
New Hampshire, Durham	May 22	May 28	June 6

MATERIALS.—The basic formulations used in each 100 gallons of spray were:

1. 50% Methoxychlor wettable powder—3 pounds
2. 50% Methoxychlor wettable powder—2 pounds
   +Lead Arsenate —2 pounds
3. Lead Arsenate —4 pounds
4. Fungicide only—Suggested,
   wettable sulfur —4 pounds
   +ferbam —12 ounces

Insecticides.—The suggested formulations for insecticides were followed by all cooperators with the following slight exceptions:

Vermont in No. 3—lead arsenate, 3 pounds.
New York in No. 3—hydrated spray lime 4 pounds added.

Fungicides.—No attempt to supply uniform fungicides was made and there were several variations from the suggested materials and dosages. This was due largely to the supplies available and to local practices, but there is no information to indicate that the results were affected. The variations which were uniform in all plots were:

Massachusetts (Amherst)—wettable sulfur 3 pounds.
New York (Poughkeepsie) wettable sulfur 3 pounds, soluble nitrogen[2] 5 pounds.
Connecticut (New Haven)—70% paste sulfur 4 pounds, ferbam 8 ounces
Rhode Island (Kingston)—no sulfur; ferbam 2 pounds.
New Hampshire (Durham)—calyx and first cover spray, 10% phenyl mercuri acetate[3] 8 fl. oz. Second cover spray, no fungicide.

METHODS OF SAMPLING.—Each cooperator selected the number of count trees necessary to give representative samples according to the size, shape and location of the experimental plots, and the assistance and time available. These varied from 2 to 17, and averaged 5.

Samples of apples to be examined were selected according to the method which each investigator had found satisfactory in previous work. Since most of the fruits in which the grubs of the plum curculio develop fall prematurely, very complete records were taken on dropped apples. In New York; Storrs, Connecticut; Amherst and Waltham, Massachusetts, all drops under the count trees were examined. In Rhode Island; New Haven, Connecticut; and Bennington, Vermont, dropped fruits from under half of the count trees were checked, and in New Hampshire from under one-fourth of each tree. In several places the collection of dropped apples was facilitated by spreading a cloth under the count trees.

It was hoped that all harvested fruit from the count trees could be examined but this was done only at Poughkeepsie,

[1] Whitcomb, W. D. Relation of Temperature to Curculio Activity, Massachusetts Bulletin 285. 1932.
[2] *NuGreen*.
[3] Puratized Apple Spray.

Table 2.—Fungicide only. (Wettable sulfur 3 or 4 pounds+ferbam 0.5 or 0.75 pound-100.)

Location	Variety	Apples Examined	Apples Stung	Per Cent Stung		
				Max.	Min.	Ave.
Massachusetts						
Waltham	Baldwin, Starking	2,831	2,409	87.99	73.50	85.09
Amherst	R. I. Greening, Gravenstein	7,167	5,859	87.13	74.55	81.75
New York						
Poughkeepsie	McIntosh, Cortland	11,745	8,126	80.07	55.95	69.19
Rhode Island						
Kingston	Cortland	8,111	4,560	59.31	44.65	56.22
Connecticut						
Storrs	McIntosh	4,499	1,480	33.57	28.79	32.90
New Haven	McIntosh	19,318	3,069	20.61	15.61	15.88

New York and Waltham, Massachusetts. The most popular method for sampling harvested apples was to examine two or three boxes per tree, or 200 apples per tree, and calculate the result on the basis of total yield and average number of apples per box. In Rhode Island, the apples in one-fifth of the boxes were examined, while at Amherst, Massachusetts, sample fruits were picked at random from the ower, central and upper parts of the tree.

Results.—Throughout the area, the infestation of plum curculio was extremely high and caused an exceptionally large amount of damage where only fungicides were applied. Although the average percentage of stung fruit in all localities was 47.52, damaged apples in Massachusetts reached 81.75 per cent and 85.09 per cent. Even at New Haven, Connecticut, where the counts showed 15.88 per cent stung fruit, it was reported that 85 per cent of

Table 3.—Lead arsenate 4 pounds per 100 gallons.

Location	Variety	Apples Examined	Apples Stung	Per Cent Apples Stung		
				Max.	Min.	Ave.
Vermont						
Bennington	McIntosh	1,417	16	1.29	0.74	1.13
Connecticut						
New Haven	McIntosh	17,572	318	2.00	0.65	1.81
Rhode Island						
Kingston	Cortland	8,690	344	5.41	3.53	3.96
Connecticut						
Storrs	McIntosh	4,511	183	4.15	3.82	4.06
New York						
Poughkeepsie	Cortland, McIntosh	31,595	1,867	6.94	4.35	5.91
Massachusetts						
Amherst	R. I. Greening, Gravenstein	5,818	402	8.00	6.00	6.91
Massachusetts						
Waltham	Golden Delicious	2,984	322	12.00	7.29	10.79
New Hampshire						
Durham	McIntosh	9,760	1,924	25.18	18.08	19.71

Table 4.—Fifty per cent methoxychlor-lead arsenate (2-2-100).

LOCATION	VARIETY	APPLES EXAMINED	APPLES STUNG	PER CENT STUNG		
				Max.	Min.	Ave.
Connecticut New Haven	McIntosh	20,599	95	0.51	0.00	0.46
Massachusetts Waltham	Golden Delicious Macoun	5,402	28	0.60	0.31	0.52
Vermont Bennington	McIntosh	1,315	13	1.00	0.96	0.99
Rhode Island Kingston	Cortland	8,351	112	1.79	0.00	1.34
Connecticut Storrs	McIntosh	4,932	145	2.98	2.84	2.94
New York Poughkeepsie	McIntosh Cortland	20,550	650	3.65	2.22	3.16
New Hampshire Durham	McIntosh	24,229	934	5.85	3.28	3.85
Massachusetts Amherst	R. I. Greening Gravenstein	5,766	418	8.07	6.11	7.25

the fruit on a nearby unsprayed tree was damaged indicating a heavy potential infestation in that area.

Previous work[1] has suggested that the general infestation tends to be less on McIntosh and Cortland than on other

[1] Whitcomb, W. D. The Plum Curculio in Apples in Massachusetts. Massachusetts Bulletin 249, 1929.

Table 5.—Fifty per cent methoxychlor wettable powder 3 lbs. in 100 gallons.

LOCATION	VARIETY	APPLES EXAMINED	APPLES STUNG	PER CENT APPLES STUNG		
				Max.	Min.	Ave.
Vermont Bennington	McIntosh	1,419	9	1.21	0.40	0.63
Connecticut New Haven	McIntosh	18,495	135	0.74	0.42	0.73
New York Poughkeepsie	McIntosh Cortland	39,398	560	1.79	0.84	1.42
Rhode Island Kingston	Cortland	12,960	227	1.91	1.18	1.75
Massachusetts Waltham	Baldwin Macoun	4,378	129	3.39	1.96	2.95
Connecticut Storrs	McIntosh	5,339	171	5.15	2.55	3.19
Massachusetts Amherst	R. I. Greening Gravenstein	4,016	179	4.88	4.05	4.46
New Hampshire Durham	McIntosh	26,175	1,673	6.94	3.94	6.39

Table 6.—Summary.

Basic Formula	Apples Examined	Apples Stung	Per Cent Stung		
			Max.	Min.	Ave.
50% Methoxychlor 3 lbs.	112,200	3,083	6.39	0.63	2.75
50% Methoxychlor 2 lbs. Lead Arsenate 2 lbs.	91,144	2,395	7.25	0.46	2.63
Lead Arsenate 4 lbs.	82,347	5,376	19.71	1.13	6.53
Fungicide Only[1]	53,671	25,503	85.09	15.88	47.52

[1] New Hampshire and Vermont data incomplete and omitted.

varieties which bloom and set earlier. This indication was supported where the average infestation in six tests on McIntosh and Cortland averaged 50.77 per cent, and in two tests on other varieties, 82.69 per cent. At Amherst, Massachusetts, where Rhode Island Greening and Gravenstein trees were interplanted in the test orchard, the infestation on the former was 71.1 per cent compared to 96.4 per cent on the latter.

In these tests the infestation counts from fungicide treatment in Vermont were incomplete and this treatment was not applied in New Hampshire. Consequently, the records from these localities were not included in table 2.

Lead arsenate has been the standard insecticide for the control of this pest on apples in New England and the Hudson Valley, but recently it has permitted 5 per cent to 20 per cent damage even under experimental conditions. In the cooperative tests the damage reached 19.71 per cent in New Hampshire and 10.79 per cent in eastern Massachusetts, compared to the average of 6.53 per cent for all localities.

It is obvious in tables 4 and 5 that there was no significant difference between the effectiveness of methoxychlor and the combination of methoxychlor and lead arsenate. In five localities the results were better with the combination, and in three with the methoxychlor alone. It is noteworthy that in New Haven, Connecticut, the examination of 1,931 dropped apples from two trees, and in Rhode Island a count of 2,097 harvested apples from three trees failed to show any injury by the curculio.

Conclusions.—In a cooperative test in eight localities in six states, 50 per cent methoxychlor wettable powder at the rate of 3 pounds in 100 gallons, and 50 per cent methoxychlor wettable powder 2 pounds, plus lead arsenate 2 pounds, in 100 gallons applied in three well timed sprays averaged 97+ per cent control of the plum curculio in heavily infested apple orchards. There was no significant difference in the effectiveness of these two formulations.

Under similar conditions, lead arsenate at the rate of 3 or 4 pounds in 100 gallons gave 93+ per cent control.

Practical recommendations based on the results of these tests should be governed by the cost, availability and compatibility with other pesticides.

Chlorinated Nicotine Derivatives as Insecticides[1]

SIMONE DORMAL,[2] D. E. H. FREAR and L. E. DILLS[3]

As one of the most useful contact insecticides, nicotine is used in large quantities in most parts of the world. Although a great deal of work has been done on nocotine and those compounds chemically related to it, only a few compounds have been found which approach nicotine in toxicity toward insects. Two of these, nornicotine [2-(3-pyridyl) pyrrolidine] and anabasine [3-(2-piperidyl) pyridine] are natural products. Most of the other natural and synthetic compounds related to nocotine are not highly toxic to insects.

Since many of the newer synthetic organic insecticides contain chlorine, it was thought possible that the insecticidal properties of nicotine might be enhanced by the introduction of chlorine into the molecule. Apparently little work has been reported on the chlorination of nicotine: Geuther & Hofacker (1858) obtained "beautiful crystals," very soluble in water and insoluble in alcohol, by the introduction of chlorine gas into a solution of nicotine hydrochloride in sunlight. No other references to chlorine derivatives of nicotine were found in the literature.

In the absence of published information, it was decided to attempt the chlorination of nicotine under several different conditions, and to study the insecticidal properties of the resulting products.

CHEMICAL STUDIES.—*Materials*—Commercial 40 per cent nicotine sulfate solution was made alkaline with sodium hydroxide and subjected to steam distillation. The distillate was extracted with ether, the solvent removed, and the impure nicotine distilled through a Penn State (Whitmore & Lux, 1932) column at a pressure of 10–20 mm. The middle fractions, having a refractive index of 1.52175 at 30° C. were collected and used for further work. Commercial compressed chlorine was used throughout this work for chlorination.

Preparation of chlorinated derivatives from nicotine.—It was determined that the direct reaction between nicotine and chlorine gas was too violent to be practical, even at 0° C. The introduction of chlorine caused a mild explosion, with the liberation of heat, and the formation of tar. Further tests with various solvents and under different conditions are given briefly in table 1. The products are identified by numbers, and the yield expressed in terms of the original weight of nicotine (usually 40 grams). These and subsequent chlorinations were carried out in a 1-liter round bottom flask equipped with a reflux condenser and mechanical stirrer. Chlorine gas was bubbled through the liquid slowly, until there was no further increase in weight. Ultraviolet radiation, produced by a sunlamp[1] was used in some cases, as shown in the table. In this and all subsequent chlorinations, the product was separated from the reaction mixture by extraction. No further purification was attempted on the bulk of the product, although smaller samples of all products were purified and attempts were made to crystallize them.

Preparation of chlorinated derivatives from nicotine monohydrochloride.—The monohydrochloride of nicotine was prepared by passing dry hydrogen chloride gas into 500 grams of pure nicotine. The monohydrochloride was insoluble in nicotine, and separated as deliquescent crystals which were filtered and washed with ether. The yield, based on the weight of nicotine taken, was 91 per cent. The properties of this material agreed with the description given by Pinner & Wolffenstein (1891).

The nicotine monohydrochloride was chlorinated under the conditions outlined above. The results are summarized in table 2.

Preparation of chlorinated derivatives from nicotine dihydrochloride.—Nicotine monohydrochloride was dissolved in chloroform and dry hydrogen chloride gas passed through the solution at room temperature. The dihydrochloride was insoluble in chloroform and separated as a viscous mass which was separated from the chloroform and dried under vacuum at 40° C. After standing several days this

[1] Authorized for publication on August 29, 1950, as paper No. 1618 in the Journal Series of the Pennsylvania Agricultural Experiment Station.

[2] The work of the senior author was supported by a grant from the Belgian Institut pour l'encouragement de la Recherche en Industrie et Agriculture. She is at present on the staff of the Station de Phytopharmacie de l'Etat, Gembloux, Belgium.

[3] Professor of Agricultural and Biological Chemistry and Associate Professor of Economic Entomology, respectively, at The Pennsylvania State College, State College, Pa.

Table 1.—Summary of chlorination reactions of nicotine.

Solvent	Conc. Per Cent	Temp. °C.	Illumination	Catalyst	Weight Increase Per Cent	Character of Product
None	100	0	Light	None	—	Explosive-yields tar
Water	20	0	Dark	None	83	None-crystalline solid (1)
Water	20	0	Light	None	75	Non-crystalline solid (2)

material crystallized in long needles. The yield, based on the weight of nocotine taken, was 116 per cent. The properties of the dihydrochloride prepared by this procedure agreed with those described by Barral (1843).

The dihydrochloride was subjected to chlorination in water solution. The results of these trials are given in table 3.

Physical and chemical properties of the chlorinated derivatives of nicotine.—In table 4 are given the data on the analytical results on the 12 chlorinated products obtained in this study. The numbers in this correspond to those given in tables 1, 2 and 3 for the individual materials. The water-soluble chlorine was determined by the Mohr method, the total chlorine by the method of Stepanow, and the mean molecular weight was estimated by the Rast procedure. All of the products exhibited the same general physical properties: their colors varied from light yellow to brown, and their consistency varied from a viscous liquid to a spongy solid. Efforts to recrystallize the materials from a wide variety of solvents were unsuccessful. They were generally freely soluble in water and the lower alcohols, but were insoluble in other organic solvents. All products were extremely hygroscopic.

Discussion.—It appears from this work that the chlorination of the ring carbon atoms in nicotine is difficult to accomplish. Whether the starting material is the alkaloid itself or the mono or dihydrochloride, the final product never contained more than 11.34 per cent non-ionizable chlorine (total chlorine minus water-soluble chlorine). Chlorination of nicotine dihydrochloride gave substances having larger percentages of non-ionizable chlorine than either the free alkaloid or the monohydrochloride.

To further complicate the chlorination reaction, there appears to be a concurrent condensation reaction, with the elimination of hydrogen chloride. Molecular weight estimations indicate that under certain conditions the polymers may contain 15 or more nicotine molecules. It is possible that two molecules of chloronicotine dihydrochloride resulting from the chlorination form a quaternary ammonium compound, and that this condensation reaction proceeds until a number of molecules are connected together in this way. The analytical results on the preparations appear to support this theory. The physical and biological properties of the preparations also indicate the formation of polymers of this type.

Biological Studies.—The 12 chlorination products listed in the tables presented in the first part of this paper were tested biologically, using the nasturtium aphid, *Aphis rumicis* L., as the test insect, following the spraying procedure described previously by King *et al.* (1943, 1944). All sprays contained 0.1 per cent sodium lauryl sulfate as a wetting agent and control sprayings without toxicant

Table 2.—Summary of chlorination reactions of nicotine monohydrochloride. Product in non-crystalline solid form.

Solvent	Conc. Per Cent	Temp. °C.	Illumination	Catalyst	Weight Increase Per Cent	No.
Water	25	25	Dark	None	42	(3)
Water	25	25	Light	None	50	(4)
Water	25	0	Light	None	50	(5)
Water	25	0	Dark	None	80	(6)
Chloroform	25	0	Light	None	70	(7)
Chloroform	25	0	Dark	$AlCl_3$	[1]	(8)
Chloroform	20	0	Dark	$SbCl_3$	[1]	(9)
Chloroform	20	0	Dark	I	[1]	(10)

[1] Loss in weight due to displacement of HCl.

Table 3.—Summary of chlorination reactions of nicotine dihydrochloride. Product in non-crystalline solid form.

Solvent	Conc. Per Cent	Temp. C°.	Illumination	Catalyst	Weight Increase Per Cent	No.
Water	20	0	Light	None	78	(11)
Water	20	95	Light	None	[1]	(12)

[1] Loss in weight due to displacement of HCl.

Table 4.—Analytical data on chlorinated nicotine preparations.

NATURE OF PRODUCT	TOTAL CHLORINE	WATER SOLUBLE CHLORINE	MOLECULAR WEIGHT
	per cent	per cent	
Nicotine monohydrochloride—crystals	17.82[1]	17.82	—
Nicotine dihydrochloride—crystals	29.80[2]	29.80	—
Product No.			
1—Hygroscopic brown resin	27.80	26.91	—
2—Hygroscopic brown resin	29.65	26.43	2320
3—Dark, tarry mass	29.32	27.53	3406
4—Hygroscopic brown resin	28.12	27.47	3210
5—Hygroscopic brown resin	28.64	27.68	—
6—Hygroscopic yellow sponge	33.60	23.98	1302
7—Hygroscopic yellow sponge	35.72	24.38	—
8—Hygroscopic brown resin	33.97	23.75	—
9—Hygroscopic yellow sponge	34.13	23.65	1161
10—Hygroscopic yellow sponge	33.00	23.60	—
11—Hygroscopic brown resin	29.97	27.26	—
12—Hygroscopic brown syrup	31.60	28.02	—

[1] Theoretical chlorine content 17.88 per cent.
[2] Theoretical chlorine content 30.21 per cent.

Table 5.—Percentage mortality of *Aphis rumicis* caused by nicotine and chlorinated nicotine derivatives.

PRODUCT	DILUTIONS[1]				
	1 to-2000	1 to-4000	1 to-8000	1 to-16,000	1 to-32,000
Nicotine (as sulfate)	93.7	90.2	78.0	69.3	56.8
Nicotine (as hydrochloride)	92.7	89.0	78.8	60.8	—
Nicotine (as dihydrochloride)	89.3	79.5	69.7	49.4	—
Product No.					
1	86.2	75.4	66.1	47.1	—
2	85.0	73.9	57.8	44.7	—
3	84.7	77.0	64.4	47.7	31.0
4	85.0	78.3	61.3	42.9	21.8
5	83.2	75.0	63.2	43.2	50.4
6	86.7	77.5	56.7	42.4	—
7	89.3	72.7	64.7	48.1	42.4
8	87.1	74.0	63.5	48.6	21.9
9	87.3	74.6	65.4	43.0	—
10	88.5	75.0	60.5	48.2	24.7
11	88.9	75.4	70.0	53.2	—
12	85.9	70.1	62.9	44.2	—

[1] Dilutions were calculated on actual nicotine content.

were made with each treatment. The results are given in table 5.

The chlorinated nicotine derivatives all showed the same general degree of toxicity to aphids. The small variations between materials appear not to be significant. All of these materials, however, showed slightly lower toxicity than either nocotine hydrochloride or nicotine dihydrochloride, and somewhat lower toxicity than nicotine sulfate.

As far as toxicity to aphids is concerned, the chlorination procedure produced little effects. Further, the variations employed in the chlorination procedure were apparently without effect on the toxicity of the final product. This is somewhat unusual, since it might be expected that ultraviolet irradiation, temperature of reaction and solvent employed would influence the composition of the final product. The slight apparent reduction in toxicity as compared with the parent material may be due to the possible polymerization mentioned earlier: although the evidence is not conclusive, it seems to support this theory.

SUMMARY.—The addition of chlorine gas to nicotine alkaloid, nicotine hydrochloride or nicotine dihydrochloride results in the formation of products which ranged in physical properties from viscous to resinous solids. No crystalline products were obtained. The maximum chlorine content obtained in any product was 35.72 per cent. Tests of these compounds on aphids indicated that chlorination did not materially affect the toxicity of nicotine. There is some evidence that polymers of a quaternary ammonium nature are formed as a result of the chlorination process.

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Comparative Susceptibility of *Septanychus texazona* and *Tetranychus bimaculatus* to Certain Sulfur and Phosphorus Products[1]

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For many years sulfur dust has been used against spider mites attacking cotton, but the results have been variable. External factors such as temperature and humidity have long been recognized to affect the toxic action of sulfur. Differences in the results obtained from the use of sulfur may also have been due to differences in species susceptibility.

Since the organic insecticides have come into widespread use for the control of insect pests on cotton, the spider mite has become a problem of major importance. Spider mite outbreaks sometimes follow the use of organic insecticides, presumably because the natural enemies of the spider mites are destroyed. Furthermore, the recent trend towards the use of low-volume sprays for cotton-insect control presents a new problem. It has not been possible to incorporate sufficient elemental sulfur into these sprays to control spider mites. Therefore a very intensive search has been going on for new materials which can be incorporated into the low-volume sprays to control the spider mites along with the insects.

Gaines *et al.* (1950) evaluated 14 compounds applied as sprays against adults of a spider mite. In field tests Iglinsky & Gaines (1949) found that sulfur and parathion were effective for the control of the same spider mite. This is the spider mite, *Septanychus texazona*, which McGregor (1950) later described from cotton in Texas.

Melvin & Earle (1948) found that a species of *Paratetranychus* was approximately five times as resistant as was *Tetranychus bimaculatus* Harvey to tetraethyl pyrophosphate. Newcomer & Dean (1949) showed that the Pacific mite, *Tetranychus pacificus* McG., and the European red mite, *Paratetranychus pilosus* (C. & F.), differed in their susceptibility to several acaricides. Garman (1950) found that certain colonies of the greenhouse spider mite became resistant to parathion but that the resistance did not appear when several other acaricides were used. Neiswander *et al.* (1950) concluded that the two-spotted mite, *Tetranychus bimaculatus*, is influenced by the host plants on which the mites feed. For example, a mite population feeding on roses is usually more resistant to acaricides than one on beans. They further state that a population subjected to the action of a dilute acaricide for three or more generations may develop a partial immunity to the material. Garman & Kennedy (1949) concluded that mite populations may easily fluctuate with the vigor of the host plant, as affected by the amount of soil fertilization.

The objectives of this study were to compare the effectiveness of four new organic acaricides, two containing sulfur compounds and two phosphorus compounds, applied as sprays against two species of spider mites attacking cotton and to compare the susceptibility of the two species of mites to each acaricide. The work was conducted in the laboratory at College Station, Texas, during the spring of 1950.

MATERIALS AND METHODS.—The sulfur-containing materials tested were Aramite (containing 2-(*p-tert*-butylphenoxy)-1-methylethyl-2-chloroethyl sulfite) and R-242 (containing *p*-chlorophenyl phenyl sulfone); and the phosphorus materials were parathion and Merthen (containing mercurated pentaethyl triphosphate and related phosphates).

The two species of spider mites were *Septanychus texazona* McGregor and *Tetranychus bimaculatus* Harvey. Both species are commonly found on cotton, *S. texazona* in the southwestern states and *T. bimaculatus* in the Southeastern States. However, both species have been reported from most of the Cotton Belt at widely scattered points. Several other species of mites of lesser economic importance are also known to occur on cotton.

Septanychus texazona prefers a higher temperature than *Tetranychus bimaculatus*, but *T. bimaculatus* prefers a higher

[1] Report of a study made under the Research and Marketing Act of 1946.

[2] In cooperation with the Texas Agricultural Experiment Station.

humidity (Iglinsky 1950[1]). The cultures of both species were therefore maintained in the laboratory near one another at a temperature and a humidity equally favorable to both throughout the tests.

The mites were maintained on seedling cotton growing in nutrient solution. It was found that populations containing at least 90 per cent of adults could be isolated by repeated transfers over certain periods of time, and plants thus infested were used in all tests. Mites on the infested plants were counted immediately before application of the sprays and 1, 3, and 5 days after application. Both species of mites were placed in the same spraying chamber and treated at the same time with the same dosage of acaricide. The plants bearing the mites were randomized in the spraying chamber, each plant in a separate vial of nutrient solution.

The materials tested were formulated in miscible oil concentrates, which were diluted with water to the desired concentrations. The sprays were applied at the rate of 21.5 gallons per acre by means of a conventional-type atomizer at a constant pressure of 40 pounds per square inch. They were discharged from the top of a plastic cylinder 32 inches high and 12 inches in diameter, the bottom of which fitted into a wooden cabinet which formed the spraying chamber, and were allowed to settle onto the infested plants for 1 minute.

Seven dosages of each acaricide were tested in determining each dosage-mortality curve. Eight plants infested with a total of about 400 mites were treated with each dosage. The dosages tested ranged from 0.001 to 10 pounds of active ingredient per acre.

The first day's record pertains principally to an adult population of spider mites. The third day's record includes the initial, delayed, and residual action against adults, the effect on egg deposition, and the residual effect on eggs and the young nymphs just hatching from eggs and beginning to feed. The fifth day's record takes into account all these factors plus the residual effect on older nymphs up to the time new adults of the next generation appear.

All stages of living mites were included in all the counts. Untreated checks were used in each test. The per cent kill was calculated by the use of Abbott's formula.

Table 1.—Dosages required to give mortalities of 50 and 95 per cent, and regression coefficients, for four acaricides against *Septanychus texazona* on cotton.

Acaricide	Pounds per Acre of Active Ingredient Required to Give— 50 Per Cent Mortality	95 Per Cent Mortality	Regression Coefficient
	1 day after application		
Aramite	0.087	0.474	2.2363
R-242	.478	3.659	1.8618
Parathion	.008	.066	1.7683
Merthon	.070	2.353	1.0786
	3 days after application		
Aramite	.112	2.044	1.1071
R-242	.636	20.990	1.0829
Parathion	.031	3,053.000	.3296
Merthon	.202	677.800	.4665
	5 days after application		
Aramite	.074	.660	1.7350
R-242	.435	7.383	1.3353
Parathion	.011	.985	.8478
Merthon	.031	139.900	.4500

The average daily temperature during this study ranged from 78.8° to 86.7° F., and the average daily relative humidity from 52.7 to 72.0 per cent.

RESULTS.—Dosages required to give mortalities of 50 and 95 per cent and regression coefficients calculated from the dosage-mortality relationships according

[1] Iglinsky, Wm., Jr. 1950. Biology and control of the red spider mites, *Tetranychus opuntiae* Banks and *Tetranychus bimaculatus* Harvey. College Station, Texas. (Thesis, Ph.D., Texas A. & M. College.)

Table 2.—Dosages required to give mortalities of 50 and 95 per cent, and regression coefficients, for four acaricides against *Tetranychus bimaculatus* on cotton.

Acaricide	Pounds per Acre of Active Ingredient Required to Give— 50 Per Cent Mortality	95 Per Cent Mortality	Regression Coefficient
	1 day after application		
Aramite	0.166	5.642	1.0745
R-242	1.712	90.490	.9546
Parathion	.057	4.109	.8853
Merthon	.155	52.240	.6564
	3 days after application		
Aramite	.150	11.130	.8793
R-242	1.946	168.400	.8492
Parathion	.134	627.000	.4483
Merthon	.175	1,429.000	.4205
	5 days after application		
Aramite	.076	6.048	.8642
R-242	1.108	83.030	.8774
Parathion	.027	.700	1.1602
Merthon	.103	6.997	.8970

Table 3.—Comparative effectiveness of four acaricides against *Septanychus texazona* and *Tetranychus bimaculatus* at the 95 per cent mortality level.

Days after application	Species of mite	Comparison[1]
1	*S. texazona*	Parathion > Aramite > Merthon = R-242
	T. bimaculatus	Parathion = Aramite > Merthon = R-242
3	*S. texazona*	Aramite > R-242 > Parathion = Merthon
	T. bimaculatus	Aramite > Parathion = (R-242 > Merthon)
5	*S. texazona*	Parathion = Aramite > R-242 > Merthon
	T. bimaculatus	Parathion > Aramite = Merthon > R-242

[1] >Significantly more effective.

to the method of Bliss (1938) are presented in tables 1 and 2.

The regression coefficients show that the slopes of the calculated dosage-mortality lines are quite different. However, in many cases the LD-50 values are approximately equal. See, for example, the 1-day records on Aramite and Merthon against *Tetranychus bimaculatus* (Table 2), and the 5-day records on Aramite against both species of mites (Tables 1 and 2). Since this experiment was designed to explain differences in the economic control of these pests in the field, comparisons would hardly be valid at the LD-50 point with the dosage-mortality lines so divergent. More appropriate comparisons are therefore made at the LD-95 level, a point indicative of economic control. These comparisons also indirectly test the significance of the differences in the slopes of the various lines.

Since the first day's mortality was also included in the third and fifth days' records, they were interpreted accordingly. Adults of *Septanychus texazona* were more susceptible to all the materials tested than were adults of *Tetranychus bimaculatus*. If there were a greater difference in susceptibility of the egg and immature stages to any given product tested than was apparent between adult stages, we would expect the third and fifth days' lines to diverge more than the first day's lines. If the difference between the two species of mites in the egg and immature stages was the same as between the adult stages, we would expect the third and fifth days' lines to maintain a constant difference with respect to the first day's lines. If the egg and immature stages of both species of mites were alike in susceptibility, then we would expect the third and fifth days' lines to converge more than the first day's lines. If the egg and immature stages of *T. bimaculatus* were more susceptible than the same stages of *S. texazona*, then we would expect the third and fifth days' lines to cross one another in a reverse direction to that of the first day's lines.

The comparative effectiveness of each acaricide against each species of mites is shown in table 3, and the comparative susceptibility of each species to all four acaricides is shown in table 4. The test for significance was based on the calculation of the fiducial limits from the dosage-mortality relationships according to the method of Bliss (1935).

Septanychus texazona was significantly more susceptible than *Tetranychus bimaculatus* to the sulfur products (Aramite and R-242). The first day's record indicates that adults of *S. texazona* were more susceptible than adults of *T. bimaculatus*. The LD-95 and regression coefficient values for these materials (tables 1 and 2) indicate that the difference in susceptibility of the two species of mites was approximately constant throughout the test period. This is interpreted to mean that

Table 4.—Comparative susceptibility of *Septanychus texazona* and *Tetranychus bimaculatus* at the 95 per cent mortality level to each of four acaricides.

Insecticide	Comparative Susceptibility After—[1]		
	1 Day	3 Days	5 Days
Containing sulfur:			
Aramite	*S. texazona* > *T. bimaculatus*	*S. texazona* > *T. bimaculatus*	*S. texazona* > *T. bimaculatus*
R-242	*S. texazona* > *T. bimaculatus*	*S. texazona* > *T. bimaculatus*	*S. texazona* > *T. bimaculatus*
Containing phosphorus:			
Merthon	*S. texazona* > *T. bimaculatus*	*S. texazona* = *T. bimaculatus*	*T. bimaculatus* > *S. texazona*
Parathion	*S. texazona* > *T. bimaculatus*	*S. texazona* = *T. bimaculatus*	*T. bimaculatus* = *S. texazona*

[1] Significantly more susceptible.

S. texazona was likewise more susceptible than *T. bimaculatus* in the egg and immature stages.

Adults of *Septanychus texazona* were significantly more susceptible than adults of *Tetranychus bimaculatus* to the phosphorus products (parathion and Merthon) as the first day's record in table 4 indicates. The LD-95 and regression coefficients for parathion (Tables 1 and 2) and the test of significance (Table 4) after 3 and 5 days indicate that the egg and immature stages of both species of mites were equally susceptible to parathion. Similar data for Merthon indicate that the egg and immature stages of *T. bimaculatus* were more susceptible to Merthon than were the same stages of *S. texazona.*

The comparisons in table 3 were based upon the LD-95 values shown in tables 1 and 2. Parathion was highly effective against adults of *Septanychus texazona.* Aramite was also effective against adults of *S. texazona.* Aramite compared favorably with parathion for the control of an entire population of *S. texazona.* Parathion was effective in controlling an entire population of *Tetranychus bimaculatus.*

These results indicate the importance of determining the species of mite present in cotton fields, so that proper materials and dosages may be applied for satisfactory control.

SUMMARY.—A laboratory study was conducted at College Station, Texas, during the spring of 1950, to compare the toxicity of two products containing sulfur and two containing phosphorus compounds to two species of spider mites attacking cotton—*Septanychus texazona* McG. and *Tetranychus bimaculatus* Harvey. The two products containing sulfur were Aramite and R-242, and the two containing phosphorus were parathion and Merthon.

Adults of *Septanychus texazona* were significantly more susceptible to all the materials tested than were adults of *Tetranychus bimaculatus.* Egg and immature stages of *S. texazona* were significantly more susceptible to the two materials containing sulfur than were the same stages of *T. bimaculatus.* In these stages both species of mites were equally susceptible to parathion, but *T. bimaculatus* was significantly more susceptible to Merthon.

Parathion was highly effective and Aramite was also effective against adults of *Septanychus texazona.* Aramite compared favorably with parathion for the control of an entire population of *S. texazona.* Parathion was effective in controlling an entire population of *T. bimaculatus.*

When the two sulfur products were applied, the significant difference in susceptibility found between the two species remained constant for all stages of the mites. When the two phosphorus products were applied, the stage of the mites greatly influenced their relative susceptibility.

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Determination of Ethylene Dibromide in Liquid and Gas Phases by the Use of Monoethanolamine[1]

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The increasing use of organic halogen compounds as fumigants for insect-infested fruits and vegetables requires that methods be available for the determination of these compounds in the fumigation chamber as well as of residues left in the product fumigated. The method generally used is hydrolysis with alcoholic KOH solution, followed by ashing of the material and determination of the potassium halide. This procedure gives good results with methyl bromide, but with other hydrocarbons such as ethylene dibromide and ethylene chlorobromide, recovery is incomplete, probably because of the formation of intermediate compounds.

Rauscher (1937) has reported the use of monoethanolamine for the hydrolysis of both aliphatic and aromatic halogen compounds. On a series of 49 compounds he obtained complete recovery of the halogens.

Stenger *et al.* (1939) used monoethanolamine to determine methyl bromide in air, and found that exposure of the sample to monoethanolamine for 15 minutes at room temperature resulted in practically complete hydrolysis. The resulting bromide was determined by the Volhard method (Hillebrand & Lundell 1929) or by Kolthoff & Yutzy's (1937) modification of Van der Meulen's method (1931).

Stenger's method was used by the writers for determination of methyl bromide in the air of a fumigation chamber, with good results; but when it was attempted to determine ethylene dibromide by the same procedure, the low recovery indicated incomplete hydrolysis. An increase in the time of standing (up to 24 hours) did not increase the yield of bromine, but a raise in temperature effected practically complete recovery. The problem, therefore, was to determine (1) under what conditions ethylene dibromide would react completely with monoethanolamine in the liquid state, (2) the conditions under which monoethanolamine would absorb ethylene dibromide from the gas phase, and (3) whether ethylene dibromide remained in the gas phase at room temperature and could be withdrawn from the fumatorium and absorbed by monoethanolamine for chemical analysis.

EXPERIMENTAL PROCEDURE AND RESULTS.—Varying amounts of ethylene dibromide (96 per cent purity) were weighed in weighing bottles, and 3 ml. of monoethanolamine was added. The stoppers were weighted to prevent their popping out, and the bottles were placed in a hot-air oven at 90° C. for 30 minutes. (Ten minutes is probably sufficient time for the reaction to become complete, but the longer time was routinely used.) The bottles were then cooled, and the contents were rinsed into a beaker and titrated by the Volhard method (Hillebrand & Lundell 1929). The results of these experiments (Table 1) show that, under these conditions, the reaction of ethylene dibromide with monoethanolamine is complete.

Table 1.—Recovery of known amounts of ethylene dibromide when dissolved in monoethanolamine.

Sample No.	Ethylene Dibromide		
	Taken (Grams)	Recovered	
		Grams	Per Cent
1	1.0781	1.0403	96.49
2	1.0827	1.0421	96.25
3	1.0740	1.0340	96.28
4	.5543	.5320	95.98
5	.5676	.5435	95.75
6	.5754	.5522	95.97
7	.7027	.6709	95.47
8	.6928	.6741	97.30
9	.2727	.2643	96.92
10	.2675	.2568	96.00
Mean	—	—	96.24

The next step was to determine the conditions under which monoethanolamine would absorb ethylene dibromide quantitatively from the gas phase. One-liter boiling flasks with ground necks were fitted with inner joints carrying glass stopcocks. The ethylene dibromide was

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[1] Paper No. 700, University of California Citrus Experiment Station, Riverside, California.

Table 2.—Recovery of ethylene dibromide absorbed by monoethanolamine in the gas phase.

Sample No.	Ethylene Dibromide		
	Taken (Milligrams)	Recovered	
		Milligrams	Per Cent
1	51.2	49.5	96.68
2	59.9	57.7	96.33
3	61.0	58.7	96.23
4	45.3	43.8	96.69
Mean	—	—	96.48

weighed in a small sealed bulb and placed in the flask. A small piece of plane glass was introduced and placed on top of the bulb. The bulb was crushed by tapping the plate with a glass rod. (The glass plate prevents the fumigant from coming in contact with the rod.) The rod was immediately withdrawn and the flask was closed by the adapter. The flask was heated in the immediate vicinity of the ethylene dibromide to vaporize it. The flask was then cooled to create a slight negative pressure, and 3 ml. of monoethanolamine was run in through the stopcock. The whole flask was warmed while being rotated to distribute the monoethanolamine, and was placed in the oven at 90° C. for 30 minutes. The flask was then cooled, and the contents were rinsed into a beaker and titrated as before. The results (Table 2) show that, on the average, 96.48 per cent of the weight of the sample was absorbed from the gas phase by monoethanolamine. The close agreement of the results with the stated purity of the material indicates that monoethanolamine can be used in the method to determine ethylene dibromide in either the liquid or gas phase.

It was next desired to know whether the ethylene dibromide remained in the gas phase at room temperature, and whether representative samples of the gas could be withdrawn from a fumatorium and absorbed by monoethanolamine for chemical analysis. For this purpose, a small fumatorium was constructed, consisting of a pyrex glass bottle of 9640-ml. capacity, closed with a rubber stopper coated with tinfoil, and carrying two glass stopcocks, the stem of one stopcock terminating just below the stopper, and the stem of the of the other extending to the bottom of the bottle. A strip of sheet metal was also

Table 3.—Recovery of ethylene dibromide from samples of gas withdrawn from a laboratory fumatorium.

Sample No.	Ethylene Dibromide		
	In Fumatorium (Milligrams)	Recovered	
		Milligrams	Per Cent
1	199.5	190.0	95.23
2	178.2	173.4	97.31
3	296.7	285.5	96.22
4	265.2	253.2	95.48
5	209.6	197.2	94.08
6	186.0	180.9	97.26
7	168.5	161.3	95.73
8	150.5	143.2	95.15
9	94.0	91.4	97.23
10	84.0	77.8	92.62
11	75.0	72.1	96.13
Mean	—	—	95.68

introduced to aid in mixing the gas within the bottle.

A sample of ethylene dibromide was weighed in a sealed ampule and crushed under a glass plate in the bottle, as described above. The bottom of the bottle was warmed to vaporize the ethylene dibromide. Then the bottle was rotated, and the strip of metal served to mix the gas with the air. Samples were taken in the 1-liter flasks used in the preceding experiment. The effective volume of each was measured by adding 3 ml. of monoethanolamine and evacuating with a high-vacuum pump. Water was then allowed to flow in to relieve the vacuum, and the volume of the water thus drawn in was measured. (The flasks must be dry inside for sampling the air-gas mixture in the fumatorium.) Three milliliters of monoethanolamine was pipetted into the flask, the air was exhausted, and the stopcock of the flask was connected by means of a short rubber tube with the stopcock which had its stem extending to the bottom of the bottle. The two stopcocks on the bottle were opened first, and then the one on the flask; a sample of gas was thus drawn from the bottom of the bottle and replaced with the room air in the top of the bottle. All stopcocks were then closed, and the flask was disconnected and placed in an oven at 90° C. for 30 minutes. After the flask had cooled, the contents were rinsed out and titrated as before. The data in table 3 show the percentage recovery of ethylene dibromide from samples of gas withdrawn from the fumatorium in

which known amounts of the material had been evaporated and thoroughly mixed. Based on the purity (96 per cent) of the ethylene dibromide used, the average recovery of 95.68 per cent was equivalent to 99.67 per cent of the total halogen of the sample.

SUMMARY.—It has been demonstrated that under the right experimental conditions, monoethanolamine will react completely with ethylene dibromide in the liquid state and will absorb ethylene dibromide from the gas phase from a sample of air withdrawn from a fumatorium. From the results of these reactions it is concluded that the total bromine content of an air sample from a fumatorium can be determined by chemical analysis, and the ethylene dibromide equivalent calculated.

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Hazards in the Use of Parathion for Greenbug Control

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An outbreak of greenbug, *Toxoptera graminum* (Rond.), in the early spring of 1950 threatened to wipe out the winter wheat crop over a large part of Oklahoma. It followed an unusually cool and wet summer in 1949, and a mild winter with below-normal rainfall from October to March in 1950. Although this was by no means the only severe threat to the wheat in the area by greenbugs, it came at the only time when high prices and effective insecticides made chemical control feasible. The wheat farmers of the state had had practically no previous experience in chemical control of insects. It is estimated that a total of not over 500 acres of wheat in Oklahoma had ever been sprayed previous to the 1950 season. The total number of acres treated with insecticides in 1950 has been estimated at from 650,000 to 1,100,000, the latter figure being a compilation of estimates of the county agents of the state. Most of the acreage was treated with emulsifiable parathion formulations. The usual rate of application was 0.2 to 0.3 pound of actual parathion per acre. In 1951, an even more extensive control program was followed, using the same formulations and spraying extensively from March until May. Protective precautions were more widely distributed and followed in the 1951 season: one fatality occurred.

Thus, the history of the 1950 greenbug control program with parathion affords an unusual opportunity to study the hazards of handling emulsifiable concentrates of this insecticide. Extreme need for control measures occurred at the windy spring season when dust application on an extensive scale was impossible. The use of emulsifiable formulations was dictated by the availability of planes equipped only for spraying, or of low capacity sprayers suitable for application of concentrates from the ground. The agitation mechanisms of such equipment was inadequate to keep wettable powders in suspension. The greater portion of the acreage was treated by aircraft operators who had had previous experience with other insecticides, but most of the local operators and the farmers were inexperienced in the application of the more hazardous insecticides such as parathion. It is estimated that about 270 persons handled parathion in connection with aircraft application, and 110 in

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connection with commercial ground applications. In addition, a great many growers, perhaps the majority, applied parathion to their own crops and cooperated with neighbors on a non-commercial basis. It is interesting to note that two of the four most serious cases of poisoning occurred in the latter category. It is also, of interest to note that the serious poisoning incidents occurred after repeated handling of parathion rather than in initial contacts.

This study of hazards from the use of parathion is the result of following up the rumored and reported cases of poisoning to man and animals, rather than of a systematic survey or random sampling of any given area. However, it is believed that it does include all cases of fatal or near fatal poisoning which occurred in Oklahoma. Needless to say, there were many rumors of serious, or even fatal, poisoning which were without foundation in fact. Some of these reports traveled widely and rapidly and gave rise to much unfounded alarm.

Parathion was officially released for greenbug control on February 22, 1950, but it was not until the second week of March that adequate supplies of the emulsifiable concentrate became generally available to commercial operators and interested farmers.

By the close of the greenbug season in May, the total poisoning casualty record was as follows:

a. One reported death by heart disease complicated with parathion poisoning; another fatality in 1951.

b. Three hospitalized cases with severe poisoning, but prompt recovery.

c. Numerous cases of severe to slight intoxication treated by physicians, but not hospitalized.

d. The death of one cow and one dog.

The fatalities and more serious poisoning cases are discussed here in some detail to analyze the errors in handling which probably led to the intake of the parathion.

FATALITIES RELATED TO POISONING.—Mr. S. had been active in the dispersal and sale of emulsified parathion. He had not flown planes in actual application, but had been active both in loading them and in filling small containers with concentrate sold to farmers and jobbers in his area. This activity and contact with parathion had lasted about 4 weeks preceding the onset of acute symptoms. Severe symptoms occurred on Sunday following contacts while loading planes on Friday and Saturday, when the patient had breathed concentrated fumes on several occasions. The concentrate had splashed on the sleeve of his jacket on Saturday. He was taken to a hospital on Sunday and died on Thursday evening after apparent recovery on Wednesday. His death was attributed "due to heart failure caused by parathion poisoning."

The 1951 fatality occurred with a farmer accidentally ingested parathion and died before he could receive medical attention. The parathion was apparently confused with water or some other beverage and swallowed from a jug which had been used in measuring out parathion emulsions for dilution in a spray tank. Symptoms were typical and death occurred within 30 minutes.

A case of poisoning occurred when a farm foreman made the following errors in handling parathion: (1) He transported lots of 25 per cent emulsion in 5-gallon cans in his private automobile; fumes became so strong he was forced to stop and open all car windows. (2) He worked 1.5 hours at adjusting a home made sprayer and making applications of concentrated sprays. During this time inadequate mask protection was afforded, and pants and shoes became soaked. (3) He neglected to consult medical help for 18 hours after severe poisoning symptoms had set in. He returned to work part of this time —again with parathion application. (4) When a concentrated emulsion splashed on his face mask, goggles, neck, and face, only a handkerchief was used to wipe off the material. (5) After less than a week of medical treatment, hospitalization and recovery time, he again contacted parathion while cleaning up his automobile, and was again hospitalized, very seriously ill.

Another worker contacted parathion in small amounts for several days, then breathed a large amount of concentrated fumes when a mask slipped from his face while he continued to charge a spray tank with the concentrate. He recovered after hospitalization. A tractor driver worked regularly for 3 weeks at dilute spray application, and on one occasion was hit in the back and neck by dilute

spray. He failed to change clothes, and became seriously ill for several days.

OTHER CASES OF DANGEROUS EXPOSURE.—A pilot of a plane was exposed to a dangerous amount of parathion when a tank of dimethyl parathion was overfilled and the overflowing material soaked his back and head. The material was washed off as soon as the tank was emptied and a landing could be made; no symptoms followed. In another case, a spray line broke within the cabin while the plane was airborne, and the pilot held the line in his gloved hand to prevent spraying aroung the cockpit. Several minutes of such exposure were experienced. Mild poisoning symptoms followed.

A number of cases of mild poisoning were reported by operators of ground rigs and by flagmen who marked swaths for aircraft application.

Other cases of poisoning were reported when welders used torches to repair tanks and wing struts of planes previously used in application of parathion sprays.

In spite of warnings and recommendations to the contrary, many 5-gallon parathion emulsion containers were seen in use as slop-pails and water buckets on Oklahoma farms.

HAZARD TO LIVESTOCK AND WILDLIFE.—A dog which persisted in chasing a plane used to apply parathion spray died following a day of such activity. He was observed to be in the direct path of the spray on several occasions and ran through grain fields as applications were being made.

On several occasions, livestock inadvertently gained access to fields very soon after they were sprayed. On only one occasion did a death result, and in most cases, no poisoning symptoms were discernible, The cow which died was one of several which had been on dry feed, but grazed in a field 3 days after the insecticidal application had been made. Three cattle of the many exposed became sick, and after being off feed 2 days, the one cow died on the third day; the others recovered. The cow which died was 7 to 8 years old, of mixed breed, and due to calf. Another cow of the group which had been sick delivered a normal calf within 2 weeks. It seems probable that the sudden change from dry to green feed may have induced a greater intake of material, and possibly complicated the poisoning; in several other somewhat comparable cases, no poisoning symptoms were noted in cattle and horses feeding accidentally on recently sprayed wheat plants.

No rabbits or birds were found dead or affected, although a considerable effort was directed toward determining possible deleterious effects on wildlife of the extensive parathion applications.

DISCUSSION.—It is the opinion of the authors that the following measures might be of considerable value as a supplement to the usual list of precautions provided on labels or supplied by manufacturers. It is recognized that in each case discussed in this paper there were many violations of the recognized necessary precautions.

1. The medical profession in affected areas should be thoroughly contacted and informed as to proper diagnosis and treatment.

2. All personnel in auxiliary jobs should be informed of hazards and be properly protected. This includes flagmen, tractor drivers, and repairmen who work on equipment which has been employed in parathion applications.

3. Containers of suitable size should be provided by manufacturers so that "home container lots" and repackaging by farmers would be avoided. Fifty-five gallon drums were notorious in promoting "subsampling."

4. Some provision should be made to destroy used containers.

5. Shoes seem to be an important source of parathion intake, and where contaminated, may be especially hazardous because of usual daily use of a single pair of work shoes.

SUMMARY.—The spraying of over 2.5 million acres of wheat with emulsifiable parathion formulations involved a number of cases of severe poisoning and two reported fatalities. Where reasonable precautions were taken, cattle, and other livestock were not adversely affected in sprayed areas. There were no observed deleterious effects on wildlife. A number of precautions are suggested to increase safety in the use of parathion formulations.

Importation of Natural Enemies to Control the Oriental Fruit Fly in Hawaii

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With the discovery of the oriental fruit fly, *Dacus dorsalis* Hendel, in Hawaii in 1946 and its rapid increase to epidemic proportions, there was immediate interest in the possibility of controlling its ravages through the introduction of natural enemies from abroad. Eradication was considered impracticable because of the continual reinfestation from vast areas of wild hosts, particularly the common guava.

Dacus dorsalis, in its various forms, is known to occur from the Malay Archipelago northward to Formosa, and from India eastward to the Philippines, the Marianas, and Hawaii. Several species of parasites were also on record from certain of these areas, including those reared during earlier investigations on the Mediterranean fruit fly.

Accordingly, in 1947 the Territorial Board of Agriculture and Forestry initiated exploration for natural enemies on the island of Luzon in the northern Philippines. Shipments received from L. B. Uichanco and Q. C. Chock contained the larval parasites *Opius longicaudatus* (Ashm.), *O. persulcatus* (Silv.), *O. incisi* Silv., and *Syntomosphyrum indicum* Silv. However, propagation was largely unsuccessful, and only a few adults were subsequently liberated. These shipments also contained the staphylinid predator *Thyreocephalus albertisi* (Fvl.), which is still being propagated and released in Hawaii, though without evidence of general establishment as yet. The Board then dispatched another entomologist to Malaya in the spring of 1948 to continue the search for fruit fly enemies.

In 1948 a cooperative project was organized in Honolulu between the Territorial Board, the Bureau of Entomology and Plant Quarantine, the University of Hawaii Agricultural Experiment Station, the Hawaiian Sugar Planters Association Experiment Station, and the Pineapple Research Institute (Carter 1950). This project was completely activated by January 1, 1949.

In July 1949 the University of California joined the undertaking and, in addition to extending foreign exploration to the Orient, is now developing techniques for the mass culture of parasites for use in California in the event of fruit fly invasion there.

Project responsibilities have been divided by mutual agreement as follows: (1) Foreign exploration by the various agencies, both jointly and individually, now mainly by the Bureau; (2) reception and quarantine handling of foreign shipments by the Bureau; (3) testing and biological studies of imported species, Bureau and Territorial Board; (4) propagation and liberation of natural enemies by the Territorial Board; (5) field recovery and evaluation of introduced species by the Hawaii Agricultural Experiment Station.

Because of the difficulties previously encountered in obtaining sufficient numbers of living vigorous parasites of the Mediterranean fruit fly from shipments of adult insects, an advisory committee of representatives from each organization recommended the importation of living host material and its rearing under strict quarantine in Honolulu. It was felt that adequate facilities were available and that such material could be safely handled under careful supervision. This procedure was approved by the Bureau, and in January 1949 the receiving work was transferred to the Pineapple Research Institute quarantine room.

To avoid any danger of escape *en route*, the fruit fly puparia are enclosed in double cloth bags within sturdy wood boxes. These are shipped to Honolulu by air express or air mail, according to the schedules and facilities available at point of origin.

The emerging flies are killed and turned over to D. Elmo Hardy of the University of Hawaii Experiment Station for identification, and the parasites are determined by the Bureau's Division of Insect Identification or by D. T. Fullaway at the Territorial Board. It should be pointed out, however, that the taxonomy of the fruit flies and their parasites is sadly in

[1] Ably assisted in the laboratory by S. Shimono.

need of basic revision and the names used in this paper are therefore tentative only. Such studies are now under way and should eventually furnish a tremendous backlog of information on the identity and distribution of fruit flies and their natural enemies throughout most of the world. This information will be invaluable in case other species "explode" into new areas as the oriental fruit fly has done in Hawaii.

The receiving and testing of imported species through September 1950 are briefly summarized in the following pages, in so far as present identifications will permit.

MALAYA.—Following the unsuccessful outcome of the Philippine venture, the Territorial Board sent N. L. H. Krauss to Malaya in April of 1948 to continue exploration in this new region. From headquarters at Kuala Lumpur and Singapore, and despite difficulties imposed by native uprisings, in the ensuing year he sent to Honolulu 85 shipments containing nearly 340,000 fruit fly puparia, most of which were *Dacus dorsalis* reared from fruits of carambola. These puparia produced some 19,000 adult parasites of about 14 different species. Approximately 90 per cent were the same species of *Opius* previously obtained from the Philippines, namely, *persulcatus*,[1] *longicaudatus*, and *incisi*. By the end of 1948 the Board had received and liberated large numbers of these parasites and recoveries were being obtained from field-collected fruits. Establishment soon resulted and the first two are now showing great promise in the biological control of *D. dorsalis* (Bess *et al.* 1950).

The cynipid larval parasite *Trybliographa daci* Weld (1951) is still being propagated and released in Hawaii but has not been recovered. The other species received from Malaya either could not be propagated from the small numbers reared or they already occurred here.

AUSTRALIA.—Krauss then moved to Australia where he spent most of the next 10 months investigating fruit flies and their parasites in the vicinity of Cairns in northern Queensland. Although it is now quite certain that *Dacus dorsalis* does not occur in Australia, this region contains an exceptionally rich fauna of endemic dacine species which we hoped might yield natural enemies capable of developing on the Hawaiian fruit flies. Some 35 species were uncovered during this investigation, several of which are described by Hardy (1951) in a revision of the entire group.

We received 55 shipments containing nearly 355,000 puparia reared by Krauss from 23 different kinds of fruit. These produced over 42,000 adult parasites of 13 species, including nearly 27,000 adults of at least five different *Opius*, several recently described (Fullaway 1950).

Despite 205 separate breeding tests with the Australian *Opius* on all three of the Hawaiian flies under a wide variety of conditions, only one species, *Opius kraussii* Fullaway (1951), was successfully cultured and that on *Ceratitis capitata* (Wied.). *O. kraussii* is now being liberated in areas where *C. capitata* is most numerous. The other species were unable to adapt themselves to the local fruit flies.

More than 15,000 adults of a cynipid *Trybliographa* sp. (apparently identical with *T. daci* from Malaya) were also reared from these puparia; it is being bred and released in Hawaii along with the Malayan form, as is the Australian race of *Dirhinus giffardii* Silv. which develops as a pupal parasite. Other reared pupal parasites of the genera *Spalangia*, *Pachycrepoideus*, and *Galesus* were already present in Hawaii or were eliminated because of their hyperparasitic tendencies.

A brief search was also conducted in the vicinity of Rabaul on the island of New Britain, but fruits were very scarce at that season and no new parasites were obtained from the three small shipments received. A short survey of the New South Wales coast was likewise unproductive.

New Caledonia and Fiji.—From headquarters at Noumea, Krauss next explored the island of New Caledonia from May to mid-August 1950. Although most fruits were then out of season, he succeeded in sending to Honolulu about 70,000 puparia in 25 shipments, collected largely from the common guava. These yielded four species of fruit flies (though not *Dacus dorsalis*) and 842 adult parasites of five species, the majority being two apparently undescribed *Opius* related to *incisi* and *longicaudatus*. Several adults of a third *Opius*, a small *Pseudeucoila*, and about 90 *Spalangia philippinensis* Full. also issued from this material. The latter has been present

[1] Apparently not the true *persulcatus* of Silvestri but a complex consisting of *Opius oophilus* Fullaway (1951) and another species of uncertain taxonomic status (van den Bosch & Haramoto 1951).

in Hawaii for many years.

After repeated attempts a breeding stock of the *Opius*, near *O. longicaudatus*, was finally established on *Dacus dorsalis* and is now being increased for eventual liberation. The other *Opius* could not be propagated.

Several weeks were then spent in Fiji en route to Honolulu, but work was prevented by the scarcity of fruits. Krauss will return to Fiji whenc onditions are more favorable.

AFRICA.—Like Australia the African continent supports a very rich though entirely different fruit fly and parasite fauna, also outside the range of *Dacus dorsalis*, as earlier exploration for parasites of the Mediterranean fruit fly had shown. In the hope that certain of these or other undiscovered natural enemies might be successfully introduced into Hawaii, J. M. McGough and F. E. Skinner were sent by the Bureau to South Africa in September 1948.

The Union of South Africa was thoroughly scouted during the next 8 months and numerous fruit samples were collected for rearing, but very few parasites were obtained. Two small shipments of adult *Tetrastichus giffardianus* Silv. and several *Opius* spp. received via the Hoboken, N. J., laboratory failed to propagate on *D. dorsalis* in Hawaii.

Moving northward through Mozambique, the Rhodesias, and Tanganyika, there was little to be found at that season and the party arrived at Nairobi, Kenya, on July 4, 1949. A close search of the native forests, parks, gardens, and plantations in this area during the following 7 months yielded 37 shipments containing about 250,000 puparia and 2500 adult parasites reared mainly from wild olives, cultivated cucurbits, coffee, and the fruits of several native trees. From these we obtained about 20,000 parasites of some 14 species, including six different *Opius*, two species of *Tetrastichus* (*giffardianus* and *dacicida* Silv.) and the usual pupal parasites. Repeated attempts to propagate the various *Opius* in Hawaii were unsuccessful, but *Tetrastichus dacicida* was readily cultured on both *Dacus dorsalis* and *Ceratitis capitata* and has been widely colonized throughout the Territory though without evidence of establishment as yet.

Hoping that better results might be obtained in South Africa at a different season, McGough then returned to Eshowe for several months but was unable to rear sufficient material for shipment and resumed work at Nairobi in May 1950. Five additional shipments containing about 77,000 puparia and 9000 infested fruits from native trees in the Nairobi area produced several species of *Opius* not received previously, but these also failed to reproduce in Hawaii.

McGough is now *en route* to West Africa where the search will be continued.

NORTHERN INDIA.—Since very little was known concerning the distribution of *Dacus dorsalis* and its natural enemies in the northern part of India, a joint expedition to this region was organized early in 1949. The services of F. A. Bianchi were contributed by the Hawaiian Sugar Planters Association Experiment Station and those of I. M. Newell by the University of Hawaii Agricultural Experiment Station, expenses being shared by the latter institution and the Bureau.

From April to October that portion of the United Provinces between Ranikhet (5700 ft. elevation) and Bareilly on the northern plains was thoroughly explored and some 30,000 fruit fly puparia from *Berberis*, guava, mango, and cultivated cucurbits were dispatched in 10 shipments to Honolulu. These produced several species of *Dacus* (including *dorsalis* and *cucurbitae*) and the *Opius* of Malayan origin already established in Hawaii, of which nearly 95 per cent were *O. incisi ex* guava. Since the Indian race of *O. incisi* seemed more prolific than the Malayan one, it is also being cultured and released in large numbers.

Newell was then replaced by N. D. Waters, of the Bureau, and headquarters were moved from Ranikhet to Bareilly. Although activities were considerably limited by the general scarcity of fruits during the winter, 67 adults of a new melon fly parasite recently described as *Opius watersi* Fullaway (1951) emerged from some 22,000 puparia out of the cucurbit *Luffa* sp. This promising new *Opius* was readily propagated in Honolulu on *Dacus cucurbitae*, and is now being extensively mass-produced and colonized in hope of early establishment.

Nagpur and Poona in Central India were scouted with negative results, and attention was next devoted to the ripen-

ing fruits of *Zizyphus jujuba* at Agra infested by *Carpomyia vesuviana* Costa and parasitized by *Bracon fletcheri* Silv. Although several thousand adults of this parasite were obtained from the Indian shipments, they failed to reproduce on the Hawaiian fruit flies.

After spending 2 months with the new South India party, Bianchi returned to Honolulu early in July 1950, leaving Waters to continue the work in northern India. From May through September we received nearly 300,000 puparia reared at Bareilly from cultivated cucurbits, peaches, mangoes, and several lesser hosts, but only two species of *Opius* were bred in small numbers: 129 of the new melon fly *Opius* from cucurbits, and 12 adults of *O. longicaudatus* from the peach and mango puparia. The ever-present pupal parasites which breed in the holding boxes were also reared in large numbers.

SOUTHERN INDIA.—Exploration was started by the Bureau in the vicinity of Bangalore, Mysore Province, with the arrival of Guy G. Beevor and T. C. Lawrence in February 1950. Here some 245,000 puparia were reared from the fruits of tangerine, coffee, *Ficus*, various cucurbits, *Eugenia*, mango, and *Solanum* and sent to Honolulu during the next 5 months. These produced 9 species of *Dacus* (including *dorsalis* and *cucurbitae*) and about 2300 adult parasites of 14 species—again predominantly pupal parasites of the genera *Dirhinus*, *Pachycrepoideus*, *Spalangia*, and *Galesus*.

Of particular interest were several species or color phases of *Opius* in the "*persulcatus*" complex from *Dacus* (?) *incisus* Walk. infesting tangerines in the Coorg district. However, these few adults emerged in poor condition and could not be propagated in the Honolulu laboratory.

With the departure of Lawrence in July and the general decline in fruit abundance around Bangalore, Beevor moved to the hill station of Coonoor in Madras Province where the wild *Solanum auriculatum* was fruiting heavily at elevations of 4000 to 6000 feet. These berries are yielding numerous puparia of *Dacus dorsalis* well parasitized by the same *Opius* spp. reared earlier from the tangerine material, and a special attempt is being made to culture them in Hawaii.

FORMOSA.—Since *Dacus dorsalis* was described from Formosa and several species of *Opius* not listed elsewhere were known to attack it there, this island was an early objective in the present investigation. Work was therefore started in the summer of 1949 by T. Maa and staff, employed by the University of California's Division of Biological Control as part of its contribution to the project.

During the past year they have sent to Honolulu 68 shipments totaling over 125,000 puparia of *Dacus dorsalis* reared from guava, *Eugenia*, mango, and several other common fruits. These puparia produced nearly 1800 adults of four species of *Opius*, namely, *formosanus* Full., *arisanus* Sonan, *makii* Sonan, and *?fletcheri* Silv., about 90 per cent of which were *formosanus*. There were also a few *Spalangia*, *Tachinaephagus* sp., and small cynipids.

A preliminary study of these *Opius* indicate that they may be synonymous with *longicaudatus*, "*persulcatus*," and *incisi*, respectively, although *formosanus* is apparently at least a distinct biological race of *longicaudatus* and is now being mass-produced and colonized in Hawaii. Breeding work is also being continued with *arisanus* and *makii*, pending a more detailed taxonomic study.

SOUTH CHINA.—The University of California also contributed the services of J. L. Gressitt and staff at Lingnan University, Canton, in a search for natural enemies of the fruit fly in South China. Although activities were limited by the communist occupation and the general scarcity of infestations, some 80 shipments have been received in the last 10 months.

About 100 pupae of a small staphylinid *Philonthus* sp. bred on melon fly were dead upon arrival. These were followed by more than 40,000 puparia of *Dacus latifrons* (Hend.) and several hundred miscellaneous adult parasites reared from the berries of nightshade (*Solanum* spp.) at Canton. However, only two *Opius* and about 200 *Spalangia* and *Pachycrepoideus* emerged from the *Dacus* puparia. None of the miscellaneous parasites could be bred on the Hawaiian fruit flies, and they probably developed on a lepidopterous borer which also infested the nightshade berries rather than on *D. latifrons*.

Some 5000 additional puparia, mostly of *Dacus cucurbitae* and *D. nubilus* (Hend.)

from various Cucurbitae at Canton, Hong Kong, and the Luichow Peninsula opposite Hainan, yielded only a few pupal parasites. It therefore seems unlikely that *D. dorsalis* occurs in this region, nor are there important parasites of other fruit flies there which might be useful in Hawaii.

SOUTHERN PHILIPPINES.—Leaving Africa in September 1949, Skinner first established headquarters at Del Monte on the island of Mindanao, moving later to Davao on the southern coast. He soon found that the few edible fruits are consumed before ripening and that very few vegetables or inedible wild hosts occur on Mindanao.

Despite these and other difficulties, 13 shipments containing some 54,000 puparia were sent to Honolulu during the past year. About 42,000 of these were reared from inedible fruits of the native forest tree *Dracontomelum dao*, and produced *Dacus limbiferus* (Bezzi) and more than 1800 adults of three species of *Opius*—*longicaudatus*, *?fletcheri*, and *skinneri* Fullaway (1951)—which we were unable to propagate on the local fruit flies. The remaining puparia from various cucurbits, guava, carambola, and jakfruit yielded a few pupal parasites and six additional species of *Dacus*, including *cucurbitae* but not *dorsalis*.

A brief search on the islands of Negros, Cebu, and Basilan was also unproductive and plans have been made to continue the work in North Borneo.

THAILAND (SIAM).—Exploration was started by the Bureau in this new and practically unknown region with the arrival of G. W. Angalet in Bangkok on June 7, 1950. Lying between the presently inaccessible countries of Burma and French Indo-China, Thailand should fill an important gap in our knowledge of the Asiatic fauna.

Initial efforts during the past 3 months have resulted in 13 shipments containing about 11,000 fruit fly puparia from four different hosts. These produced nearly 500 adult parasites of 6 or 7 species.

The fruits of *Zizyphus jujuba* have been the most prolific source of material yielding *Dacus dorsalis*, *Carpomyia vesuviana*, 3 or 4 species of *Opius*, including *?incisi*, *longicaudatus*, and "*persulcatus*," and the pupal parasites *Spalangia* and *Pachycrepoideus*. Only *O. ?incisi* has been successfully cultured so far. Puparia from eggplant and *Momordica* have produced 3 species of *Dacus* (including *cucurbitae*), a few of the same *Opius* and *Spalangia*, and about 75 adults of a small encyrtid which we are attempting to propagate in Hawaii.

OTHER AREAS.—In July 1949 we received 125 puparia of *Dacus ochrosiae* Mall. collected by M. M. Ross, of the Bureau, from fruits of *Aglaia mariannensis* on the island of Saipan. The eight adults (three females) of *Opius ?longicaudatus* reared from these puparia failed to breed on *Dacus dorsalis*.

In October 1949 W. E. Stone, of the Bureau's Mexico City Fruit Fly Laboratory, sent 323 adult *Opius crawfordi* Vier., an important parasite of *Anastrepha ludens* (Loew) in Mexico. Although they oviposited readily in various fruits infested by all three of the Hawaiian fruit flies, no progeny were obtained from any of these tests.

SUMMARY.—From June 1948 through September 1950, 465 shipments containing about two and one-third million fruit fly puparia and 6000 adult parasites were received in Honolulu from foreign explorers in Malaya, Africa, India, Australia, New Caledonia, New Britain, Thailand, the Philippines, Formosa, South China, Mexico, and Saipan. These shipments were made possible through a cooperative project between Federal, State of California, Territorial, and private agencies to control the oriental fruit fly, *Dacus dorsalis* Hendel, in Hawaii by the importation of natural enemies from abroad. The puparia were reared by the Bureau of Entomology and Plant Quarantine under strict quarantine, and produced numerous species of fruit flies and some 106,000 adult parasites of at least 40 different species.

Two forms of *Opius* in the "*persulcatus*" complex, *O. longicaudatus* and *O. incisi* imported from Malaya in 1948, soon became established in Hawaii and are showing great promise in the biological control of *Dacus dorsalis*. Many of the others were parasites of different fruit flies and could not be cultured on *D. dorsalis*, but several additional species are now being extensively propagated and released in hope of establishment.

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Control of House Flies with Methoxychlor in Texas Dairy Barns

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One of the recognized and legitimate requirements of clean milk production is the maintenance of control of house flies, *Musca domestica* L. House fly control may be attempted by practicing sanitation to prevent the development of larvae, by screening and by the use of insecticidal agents.

Sanitation in respect to fly development can be maintained to a reasonable degree, but the great cost of sustaining a degree of sanitation that will alone adequately control flies will usually necessitate the use of additional control measures. Furthermore, considerable numbers of flies may fly to a dairy from other premises. Bishopp & Laake (1921) have shown that house flies may be recovered 6 miles from a release point in less than 24 hours after a release is made.

The screening of dairy barns is helpful when combined with the use of an effective insecticide; but many flies will enter screened barns through open doorways and on the backs of cattle, and these flies may live for several days and accumulate in large numbers if the barn interiors are not treated with insecticidal agents.

The feasibility of adult house fly control in diary barns was greatly enhanced by the introduction of chlorinated, residual-type insecticides; and the increased attention given to the problem of house fly control with these chemical agents has been evidenced by the bulk of entomological publications on the subject since 1943.

Among the more recent technical publications dealing with practical house fly control in diary barns are those of Gilbert, *et al.* (1950), Hansens (1950), King & Gahan (1949), King (1950), Laake *et al.* (1950), March & Metcalf (1949), Muma & Hixon (1949), and Pimental *et al.* (1950). Indicated in these reports is a marked variability in initial activity and duration of effectiveness of residual deposits of various chlorinated-compound insecticides in house fly control. The need for obtaining consistently satisfactory performance from deposits of a safe, contact-type, residual insecticide is sufficient to warrant continued investigation of the best means of using such materials. This paper is a presentation of results of tests conducted in Texas during 1950 to further develop an understanding of several possible causes for variation in the length of time that house flies are well controlled in diary barns, following the application of methoxychlor deposits.

MATERIALS AND METHODS.—Fifteen dairy barns, all stiuated in South Texas were used in the tests. Two of the barns were screened, and 13 were not. The two screened barns were on the same farm, and were $\frac{1}{4}$ mile apart. The farms selected were representative of barn construction and dairy management practices in South Texas. A preliminary survey was made at each farm immediately prior to spraying. Special attention was given at each barn to the history of previous use of insecticides, the number of flies outside and in-

PAID PAPER.

[1] N. K. Talbert assisted with field tests.

side the barn and the amount of fly larval development on the premises.

Each barn was sprayed with a water suspension of 50 per cent methoxychlor wettable powder used at a concentration of 2 pounds of active insecticide to 12.5 gallons of water. The spray was applied to the run-off point to all inside barn surfaces, except on the inside of feeding troughs. Screening was sprayed in the screened barns. Application was made with a power sprayer equipped with a mechanical agitator. This procedure provided an estimated deposit of 1.0 mg. of methoxychlor per square inch of treated surface. None of the barns had been sprayed with a residual-type insecticide during 1950, prior to the tests. Methoxychlor had been used during the 2 prior years at the 2 screened barns, but had not been used previously at any of the other barns. All barns were sprayed between April 27th and May 18th, and were not re-sprayed during the course of work herein reported.

The stability of methoxychlor deposits on barn wall surfaces was determined at intervals during the observational period by measuring the knock-down time of house flies confined on the residual deposits on walls. The flies were confined in cellulose acetate cones. These cones were 4 inches in diameter and 5 inches tall. Each cone had a 0.5 inch, cotton-plugged opening at the apex, and each was fitted at the base with four cellulose acetate strips to provide for attachment, with thumb tacks, to flat barn surfaces. About 25 flies were introduced into a wall cone, and the time for 100 per cent knock-down was recorded. The cones were never used more than once on a given spot, and were only attached to walls at the time of a test. The cones were effectively cleaned by washing in water containing a detergent.

A survey of fly populations was made in each barn prior to spraying and at intervals after spraying, and fly populations outside the barns were also surveyed. A count of all flies present in a barn was made when the total number present was approximately 100 or less. Careful estimates of the total number of flies inside and outside of barns were relied upon when the number of flies was greater than could be counted with accuracy.

Particular attention was given to the habits and behavior of flies in treated barns.

All observations were made during mid-day when cows were not in the barns. The duration of observations at treated barns was 6, 7, or 8 weeks, depending on need for observations or passage of the time allotted for the tests. The barns were observed weekly during the first five weeks of the tests, and at least every 2 weeks thereafter.

Weather conditions were highly favorable during the period of the test for house fly development, activity and survival. In April the monthly mean temperature was 67.7 degrees F. and rainfall was 3.42 inches. The maximum temperature in April was 89 degrees F. The minimum temperature in April was 45 degrees F., which was on April 7th. The average temperature in May was 76.8 degrees F. May precipitation was 2.36 inches. The mean temperature in June was 80.7 degrees F., and precipitation was 1.03 inches.

RESULTS.—Results of house fly control in the barns are presented in table 1. Circumstances which developed after the tests were initiated somewhat modified the fly count data in the unscreened barns numbered 5, 7, and 11. It was later determined that these barns were all situated within a mile or less of a hog feeding establishment, and movement of flies from this plant may have affected the fly count data. Moreover, the operators of dairies numbered 5 and 11 were involved in serious accidents after the tests were started, and this resulted in relaxation of normal sanitation around the barns and premises and undoubtedly contributed to an increase in the fly population on these farms.

The failure in house fly control observed in three unscreened barns (Nos. 10, 12, 13) at the fifth, sixth, or eighth week, did not result from a diminished insecticidal activity of methoxychlor residues on barn walls. This conclusion is supported by a record of knockdown rates of flies exposed in wall cones to methoxychlor deposits in barn number 10 at intervals up to the eighth week. Similar figures on knock-down rates were obtained in wall cone tests in each of the other barns. Poor sanitation in respect to house fly larval development was observed at all three farms.

Table 1.—Effect of methoxychlor residual spray deposits on house fly populations in dairy barns.

Barn No.	Estimated Number of Flies at Dairy Before Spraying		Post-Spraying Fly Counts Inside Barn (Weekly Intervals)							
	Inside Barn	Outside Barn	1st	2nd	3rd	4th	5th	6th	7th	8th
1	20	20	2	1	0	—	0	0	0	0
2	1	50	0	5	—	1	0	—	0	—
3	10	200	0	11	0	3	0	0	0	0
4	20	100	0	0	2	0	0	—	4	—
5*	100	100	12	5	25	30	150	—	500	700
6	500	100	7	—	8	21	5	—	50	—
7*	20	1,000	1	10	60	200†	9	—	23	—
8	50	1,000	0	2	2	12	8	—	11	—
9	75	1,000	2	2	2	—	4	—	7	—
10	200	2,000	0	15	2	20	32	60	—	100
11*	100	2,000	200	120	125	—	—	1,000	5,500	—
12	1,000	5,000	5	3	2	55	31	1,000	—	—
13	1,000	10,000	2	5	8	65	218	—	1,000	—
14‡	100	5,000	20	30	100	15	—	110	25	—
15‡	100	10,000	15	75	15	30	—	230	25	—

* Post-spraying fly counts affected.
† There was an influx of flies because of rain at the time of observation.
‡ Screened barns. Other barns not screened.

Masking of methoxychlor deposits with fly excrement in favored resting places in unscreened barns surrounded by uncontrolled larval development was, we believe, a major cause of failure to derive maximum length of benefit from a single spraying. These tests have confirmed and extended the observation of Muma and Hixon (1949) who have reported that a covering or wearing away of the residues (of insecticides) by large fly populations may result in shorter control periods subsequent to the use of residual insecticides. Excrement deposits, which eventually cover insecticide residues on favored resting places, begin to accure during the lag time between initial insecticide contact and the first irritation response of the flies. Under pressure of large numbers of flies such deposits develop rapidly on wires, narrow boards, rough cracks, and surfaces on rafters or ceilings, all of which are preferred resting places.

Fly populations outside both screened barns were very heavy due to highly favorable conditions for fly larval development. Screening reduced the number of flies entering these barns from the outside and retarded their escape, thus enforcing repeated contact with methoxychlor-treated surfaces. For these reasons, screening helped to overcome failure of fly control due to the loss of activity caused by the masking of deposits by feed dusts or fly excrement. The natural tendency of flies to move about and to fly toward sources of light insured their contact with methoxychlor-treated screens and other surfaces. Fly counts in the screened barns (14 and 15) are given in table 1, but the numbers of flies may mean little, because the presence of residual deposits in a screened barn will permit relaxation in keeping doors and windows closed. Dead and dying flies were present in the screened barns through the 7th week after treatment.

A considerable increase in knock-down time in wall cone tests was encountered in some of the flies at the 2 screened barns. The increase in knock-down time did not appear to materially affect practical control of flies in these barns. At the seventh post-spraying week, when fly counts reached the point where re-spraying was deemed advisable, numerous flies found on window sills and floors exhibited typical symptoms of insecticide intoxication, indicating that residual methoxychlor deposits were still active. It is of interest that DDT was used in the vicinity of these barns during 1945, 1946, and 1947, and that methoxychlor was used as a barn spray in 1948 and 1949; however, the degree of resistance which developed in the flies was insufficient to prevent practical control with recommended deposits of methoxychlor.

Discussion.—The fly population around the dairy barns involved in these

tests could feasibly have been reduced by appropriate sanitary measures to control the most easily removed sources of fly larval development. Most of the larval development occurred in manure spreaders that were not emptied often enough or in small piles of barn wastes that were not spread when emptied from wheelbarrows. Reasonable attention given to a properly scheduled program of hauling to the fields and of thinly scattering manure and feed wastes from these barns would have permitted the dairy operators to receive the greatest and most prolonged benefit from expenditures for residual insecticides. Some masking of insecticide deposits by feed dusts and some mechanical removal of deposits from stanchions and floors are inevitable. If to these unavoidable losses are added the masking effect of fly excrement deposited by unreasonably excessive numbers of flies on insecticide deposits in favored resting places, a point is reached in unscreened barns at which house flies do not make effective contact with an insecticide-treated surface.

The results and observations reported herein were obtained in a single area, and may not be entirely representative of other places; however, good sanitation in relation to duration of fly control with residual insecticide deposits is important under all conditions.

Further studies of practical fly control in relation to degree of sensitivity to methoxychlor are being conducted.

SUMMARY.—Under conditions of these tests, methoxychlor provided at least 5 to 7 weeks' control of house flies inside screened dairy barns and in unscreened barns surrounded by premises on which good sanitation to prevent fly larval development was maintained.

A considerably increased knock-down time of methoxychlor deposits exhibited by a small percentage of house flies in wall-cone tests at two closely adjacent screened dairy barns, did not prevent practical fly control in the barns during a seven-week observational period.

Deposits of methoxychlor applied to dairy barns from a 50 per cent wettable powder formulation did not significantly deteriorate in insecticidal activity during an eight-week observational period.

Masking of methoxychlor deposits with fly excrement on favored fly resting places was evident as a major factor contributing to the failure to realize maximum benefit from this insecticide in unscreened dairy barns surrounded by uncontrolled fly larval development.

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Synergist is Action of Piperonyl Butoxide Fractions and Observations Refuting a Pyrethrins-butoxide Complex

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Piperonyl butoxide has been known as an effective pyrethrins synergist since 1947 (Wachs 1947). It is widely used in aerosol, oil-base household sprays, and other types of formulations. By official definition, the technical grade of this product is considered to be 80 per cent (butyl carbityl) (6-propyl piperonyl) ether and 20 per cent related compounds. In labeling commercial containers of insecticides, the related compounds are considered to be insecticidally active. Reports from the manufacturer[1] indicate the current technical grade material to contain higher than the minimum of 80 per cent piperonyl butoxide and give early 1946 as the date of first large-scale commercial production.

The site and mode of action of piperonyl butoxide on insects are still questionable although most workers have assumed that this and related compounds affect the nervous system (Hartzell & Scudder (1942); Lindquist *et al.* (1947); Wilson (1949); Page & Blackith (1949)). Of the several theories on the mode of synergism, that of Page & Blackith lent itself best to *in vitro* physical studies. These workers proposed the formation of a loose molecular complex consisting of pyrethrins and synergists combined in a 1:1 mole ratio. They reported this complex to be approximately three times as effective in producing paralysis of *Aedes aegypti* (L.) mosquitoes as pyrethrins alone.

In view of the lack of published information about piperonyl butoxide, it seemed appropriate to present at this time our collected data on the physical and biological properties of piperonyl butoxide fractions; spectral and cryoscopic studies are also reported which indicate no pyrethrins-butoxide complex to be formed in hydrocarbon solutions.

I. Physical Constants of Piperonyl Butoxide Fractions.—Technical piperonyl butoxide (965.40 grams) was fractionated through a 1-inch inner diameter, 18-inch length heat-jacketed column filled with Podbielniak Heli-Pak packing (size 0.092″×0.175″×0.175″) at 0.6 mm. pressure. The refractive index and specific gravity of each fraction were measured. The piperonyl butoxide content of each fraction was determined chemically by the U.S.I. method.[2]

II. Biological Evaluation of Piperonyl Butoxide Fractions as Pyrethrins Synergists.—Table 2 records three series of biological tests to evaluate the synergisticaction on pyrethrins of various piperonyl butoxide fractions. These tests by the Large-Group Peet-Grady Method employed approximately 500 flies per test unit. A solution of 0.06 per cent by weight pyrethrins (50 mg./100 ml. base oil) was substituted for the official test insecticide. The house flies were of the CSMA 1948 strain, and adults received a diet of 5 per cent spray-dried non-fat milk solids in water during the aging period prior to testing. The pyrethrins were obtained from a commercially produced concentrate containing 2.0 grams per 100 milliliters. A typical odorless-type household insecticide base oil (0.78 sp. gr. and 380 to 480° F. boiling range),[1] was used as the spray diluent. All tests within a given series were conducted on the same fly cultures, and best comparisons are consequently made within a series rather than between series. Because of technique difficulties, base oil and base oil-piperonyl butoxide combinations were not included among the test sprays. Tests by the Peet-Grady Method show mortalities in the range of 2 per cent for the base oil which are not increased appreciably by the addition of 0.045 per cent piperonyl butoxide.

Based on 24-hour mortalities, Series A shows a high activating efficiency of equal magnitude for the heart fraction composite (Fractions 4 to 8) and the technical grade piperonyl butoxide. Series B shows Fraction 1 to be completely inactive and Fractions 2 and 10, while having positive synergist action, to be

Paid Paper.

[1] Private communication from Howard Jones, U. S. Industrial Chemicals Co. (October, 1951).

[2] The authors wish to thank the U. S. Industrial Chemicals Co. for their kindness in determining the piperonyl butoxide contents listed in Table 1. The Revised Tentative Procedure For The Determination Of Piperonyl Butoxide (U.S.I., November 7, 1949) modified as to purification of tannic acid reagent (U.S.I., March 22, 1951) was used as the test method.

Table 1.—Physical constants of piperonyl butoxide fractions.

FRACTION NO.	BOILING POINT °C. AT 0.6 mm. PRESSURE	WEIGHT PER CENT	REFRACTIVE INDEX 20°C.	SPECIFIC GRAVITY 15°C./15°C.	WEIGHT PER CENT PIPERONYL BUTOXIDE
Technical Piperonyl Butoxide	—	—	1.4980	1.0568	90
1	41.0–131.5	9.41	1.4585	0.9861	15
2	131.5–175.0	9.98	1.4991	1.0568	76
3	175.0–185.5	10.16	1.4993	1.0583	92
4	185.5–187.0	10.04	1.4983	1.0575	98
5	187.0–187.0	10.08	1.4980	1.0568	100
6	187.0–187.5	10.12	1.4984	1.0568	99
7	187.5–187.5	10.07	1.4988	1.0575	100
8	187.5–188.0	10.15	1.4998	1.0583	97
9	188.0–188.0	9.94	1.5011	1.0607	94
10	Residue	8.20	1.5424	—	44
Holdup and Loss	—	1.12			
Cold Trap	—	0.73			

less effective than Fraction 3, the composite heart fraction, and Fraction 9. Series C shows Fractions 4, 5, 6, 7, and 8 and a composite of these fractions to be highly effective as synergists with approximately equal activating effect. In our opinion, the results in Series C of the composite of fractions 4 to 8 are somewhat low, and additional determinations might well increase the 73.7 per cent value to within the range for fractions 4 to 8, inclusive. In all tests, the piperonyl butoxide appears to cause a slight increase in paralysis. The effectiveness of the vari-

Table 2.—Evaluation of piperonyl butoxide fractions as pyrethrins synergists.

TEST SPRAYS[1] 0.06% by wt. Pyrethrins Alone and with 0.045% Butoxide Fractions	NO. OF TESTS	NO. OF CULTURES	10 MIN. PER CENT KD	24 HR. PER CENT DEAD
	Series A			
1. Pyrethrins Alone	6	3	97.5	23.3
2. Pyrethrins+Comp. Fract. 4-8	9	3	99.0	80.6
3. Pyrethrins+Tech. Butoxide	9	3	99.1	80.1
	Series B			
4. Pyrethrins Alone	8	4	96.7	18.7
5. Pyrethrins+Fract. 1	4	4	97.5	18.8
6. Pyrethrins+Fract. 2	4	4	98.6	65.6
7. Pyrethrins+Fract. 3	4	4	98.7	72.4
8. Pyrethrins+Comp. Fract. 4-8	4	4	99.1	74.7
9. Pyrethrins+Fract. 9	4	4	97.8	73.4
10. Pyrethrins+Fract. 10	4	4	98.1	52.0
				6.7
Diff. for signif. at 5% level (Sprays 6 to 10)				
	Series C			
11. Pyrethrins Alone	8	4	96.2	20.3
12. Pyrethrins+Fract. 4	4	4	98.9	80.9
13. Pyrethrins+Fract. 5	4	4	98.2	79.8
14. Pyrethrins+Fract. 6	4	4	98.8	77.4
15. Pyrethrins+Fract. 7	4	4	99.2	83.1
16. Pyrethrins+Fract. 8	4	4	98.4	79.5
17. Pyrethrins+Comp. Fract. 4-8	4	4	98.6	73.7
				5.0
Diff. for signif. at 5% level (Sprays 12 to 17)				

[1] Gulfspray Naphtha diluent.

Table 3.—Freezing point lowering of cyclohexane effected by pyrethrins—piperonyl butoxide mixtures.

Run No.	Solute Concentration Mole Per Cent: Pyrethrins	Solute Concentration Mole Per Cent: Piperonyl Butoxide	ΔT Calc. °C.	ΔT Found °C.	Difference °C.
1A	0.292	0.000	0.71	0.74	+0.03
1B	0.291	0.257	1.34	1.32	−0.02
2A	0.362	0.000	0.88	0.86	−0.02
2B	0.360	0.361	1.76	1.67	−0.09
3	0.000	0.273	0.67	0.71	+0.04

ous fractions appears to be related to the piperonyl butoxide content, as determined chemically, shown in table 1.

III. Cryoscopic Determinations of Pyrethrins-Piperonyl Butoxide in Cyclohexane.—Biological evaluation of the piperonyl butoxide fractions showed fractions 4 to 8 to be equally potent as synergists. A sample was prepared which was a composite of equal weights of fractions 4 to 8. All measurements were made on this composite. The pyrethrins used were furnished by Mr. Norman Earle of the Gulf Fellowship at the University of Illinois and were purified by the method of Barthel *et al.* (1944). The cyclohexane was Phillips research grade.

A series of freezing point determinations was made on the following solutions: pyrethrins in cyclohexane, piperonyl butoxide in cyclohexane, and a mixture of pyrethrins and piperonyl butoxide in cyclohexane. A modified ASTM freezing point apparatus was used.[1] Estimated accuracy of temperature determinations was ±0.05° C. Cyclohexane was used as a solvent because of its large cryoscopic constant.

The possibility of complex formation was investigated by a comparison of the calculated freezing point lowering with that found experimentally. The theoretical freezing point lowerings were calculated from the solution concentrations, cryoscopic constants for cyclohexane,[2] using 338 for the molecular weight of piperonyl butoxide, and assuming no complex formation (strictly additive freezing point effect). In the absence of definite data on the purified pyrethrins, an average molecular weight of 341 for the pyrethrins (based on an assumed composition of 35 per cent Pyrethrin I, 35 per cent Pyrethrin II, 15 per cent Cinerin I, and 15 per cent Cinerin II)[3] was used in our calculations. The data obtained are tabulated as follows:

The first series of runs (1A and 1B) gives no evidence for complex formation. The second series (2A and 2B) might suggest the presence of a complex. The difference of 0.09° C., although double the estimated accuracy of the temperature determinations, is believed to be due to other experimental difficulties. If it is assumed that 0.09° C. is a true difference, then calculation of the amount of complex formation from the data for Run 2B shows that approximately 10 per cent of the components exist as a complex. It should be noted that the per cent concentrations in table 3 exceed (by at least a factor of 10) those used in table 2. Obviously less complex would exist in the more dilute solutions. If one assumes that pyrethrins and piperonyl butoxide react

[1] ASTM Designations: D 1015-49T and D 1016-49T.
[2] Selected Values of Properties of Hydrocarbons, API Project 44, Table 7z (March 31, 1947).
[3] Private communication from F. B. LaForge (October, 1951).

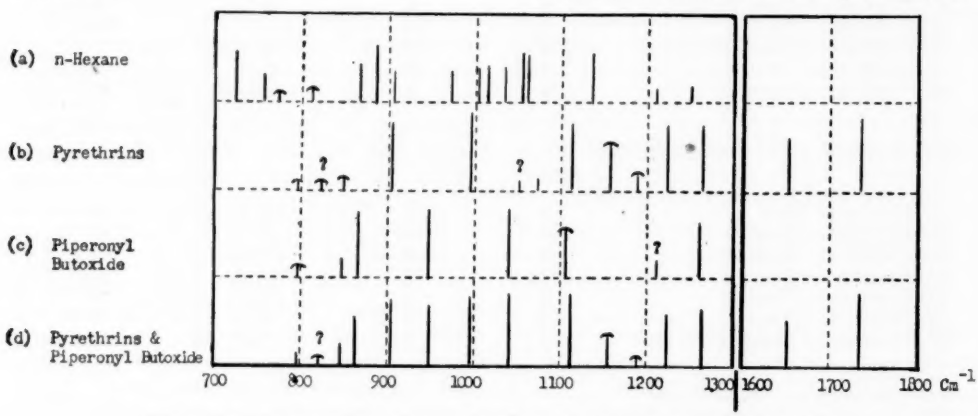

Fig. 1. Infrared absorption frequencies of pyrethrins and piperonyl butoxide.

reversibly to form a complex, and that in Run 2B 10 per cent of such a complex actually exists, then it may be calculated that approximately 0.1 per cent of such a complex could exist in the solutions used in table 2. Thus, within the limits of detection of the method, there appears to be no evidence of complex formation throughout this concentration range.

IV. INFRARED SPECTRAL STUDIES OF PYRETHRINS AND PIPERONYL BUTOXIDE.—The spectral data were obtained on a Perkin-Elmer Infrared Spectrometer modified to give automatic transmitted energy records. The purified pyrethrins and piperonyl butoxide heart fraction composite used were the same as described in the cryoscopic studies. A cell of 0.15 mm. thickness was used to obtain the spectra from 5.4 to 15 μ of (a) n-hexane, (b) 5 per cent by weight solution of pyrethrins in n-hexane, (c) 5 per cent solution of piperonyl butoxide in n-hexane, and (d) 5 per cent pyrethrins plus 5 per cent piperonly butoxide in n-hexane. In Fig. 1 the observed absorption frequencies of each of the above samples are schematically presented. The heights of the lines represent a visual estimate of the relative intensities of absorption bands. In the representations for the solutions of pyrethrins and piperonyl butoxide in n-hexane, the absorption bands of the solvent have been subtracted out of the spectrum. An umbrella over a line indicates the presence of an absorption band with a broad minimum, and a question mark over a line indicates a band whose identification is somewhat questionable

From figure 1 it can be seen that the spectrum of solution (d) is a superposition of the spectra of (b) and (c). The fact that no absorption bands disappeared or shifted in frequency when the spectrum of solution (d) was correlated with the other spectra showed that there was no detectable reaction occurring between the two solute materials in the concentrations studied The concentrations of solutes used in this study were approximately five times as great as those used in the cryoscopic study. If an equilibrium exists between pyrethrins, piperonyl butoxide, and a complex of the two solutes, it is believed that the concentration of the complex would be high enough to be observed spectrally. The absence of such an observation supports the belief that the discrepancy in Run 2B of the cryoscopic study is due to experimental difficulties and not to the existence of a complex.

V. SUMMARY.—Fractions of technical grade piperonyl butoxide were characterized physically, chemically, and biologically. Cryoscopic and infrared spectral studies on mixtures of purified pyrethrins and piperonyl butoxide gave no evidence for the formation of a molecular complex in hydrocarbon solutions.

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Control of the Pear Borer in Apple Trees

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The pear borer is the larva of a clear-winged moth, *Thamnosphecia pyri* (Harr.), which feeds in the bark and cambium of apple, pear, mountain ash, hawthorn, and juneberry. The larvae of this borer may be found in almost any old apple tree in the Valley and Piedmont areas of Virginia, and Brooks reported that it is widely distributed over the eastern United States. The feeding of the pear-borer larva is confined to the bark and cambium of the hosts. The burrows of the first- and second-instar larvae are usually in the bark, they having not yet reached the cambium. The feeding of the larger larvae causes slight grooves in the surface of the wood, but the larvae never penetrate the wood. The term "pear borer" is misleading, for this borer attacks apple much more extensively than any other host. For this reason a change of the common name to "apple bark borer" is suggested.

The presence of a few borers does not cause any appreciable effect on the health of a large tree, for the damage done by a single borer is relatively slight. In many mature and aging apple orchards in Virginia, however, the population of this borer has increased to the point that some trees have an infestation of several hundred larvae. Under such conditions severe damage results. The infestation centers around the same spots year after year, for the roughened bark of such areas is attractive to the ovipositing moths. Large cankers develop, usually on the lower surfaces of the larger branches. As these branches die from the effects of the partial girdling, the bearing surface of the tree is seriously reduced, and its general health much impaired. Many large trees have been lost in some orchards as a result of such injury. The pear borer attacks all varieties of apple, but in Virginia the heaviest infestations have been observed in plantings of the York Imperial and Rome Beauty varieties.

The eggs of the pear borer are deposited singly in slight crevices or irregularities in the bark of the trunks and branches of the hosts. Most of the eggs are deposited in the vicinity of roughened bark. Favorite spots are the cankers resulting from the past feeding of the borers. Other attractive areas are the edges of pruning wounds and beneath scales of loose bark. Although only one egg is deposited at a time, the moth may return to the same spot several times. Other moths may also deposit eggs in the same area, so that there may be several larvae in a relatively small area. The eggs hatch in a week or less, and the young larvae burrow into the bark.

Bait-trap catches of pear-borer moths over a period of 10 years in Augusta County, Virginia, show that there are two peaks of moth flight. The first of these occurs late in May, the second soon after the middle of June. Most of the eggs are deposited about the time of, or soon after, these peaks of flight.

Bobb[1] reported that about 85 per cent of the pear-borer larvae pupated and transformed the summer following their hatching, having a life cycle of about 13 months. The remaining 15 per cent did not pupate until the second spring, having a life cycle of about 20 months. Observations in Augusta County in 1950 and 1951 indicate that this division may be nearer 70 per cent and 30 per cent.

Brooks reported that the pear borer may be controlled by cutting out the larvae and painting the wounds with coal-tar creosote or white-lead paint. He also reported that kerosene-emulsion or oil-emulsion sprays containing small amounts of sodium arsenite killed 85 per cent of the borers. Willey[1] reported good results from similar applications. Bobb[1] found that spraying was not effective enough to justify its recommendation for control of the pear borer. He obtained good control with a wash, applied by brush, containing 1 pound of paradishlorobenzene in 2 quarts of cottonseed oil.

Methods and Materials.—In 1950 work was begun in the testing of some of the newer organic insecticides against the pear borer. Since a deposit of DDT on peach trunks and branches during the oviposition period of the peach-borer moths has given good control of this insect, and since the pear borer has similar habits, the sprays were timed to give a

Eastern Branch.

[1] Unpublished Thesis.

Table 1.—Results of spraying for the control of the pear borer on apple trees, Staunton, Virginia, 1950.

Materials per 100 Gallons	Dates Applied	Reduction in Infestation	
		Large larvae	Small larvae
Parathion, 25%, 3 lbs.	May 25	51%	98%
	May 25, June 13	93	100
	June 13	90	99
DDT, 50%, 8 lbs.	May 25	44	92
	May 25, June 13	0	87
	June 13	47	89
Number of borers per check tree		71	119

deposit of the toxicants on apple trunks and branches during the flight period of the pear-borer moths. In 1950 sprays containing DDT, 8 pounds of 50 per cent wettable powder per 100 gallons; and parathion, 3 pounds of 25 per cent wettable powder per 100 gallons, were used. Sprays were applied on April 29, May 25, and June 13. The schedules followed are shown in table 1.

In 1951 the same materials were tested, but at several rates of dilution. DDT, 50 per cent wettable powder, was applied at rates of 2, 5, and 8 pounds per 100 gallons; and parathion, 15 per cent wettable powder, was applied at rates of 2, 3, and 5 pounds per 100 gallons. In addition, 25 per cent ethyl p-nitrophenyl thionobenzenephosphonate,[1] was applied at rates of 2 and 3 pounds per 100 gallons. Applications were made on May 15, May 28, June 15, and July 3. The schedule of applications of each treatment is given in table 2. Some of the trees that had been sprayed in 1950 with DDT and parathion were again sprayed with the same materials in 1951 to determine the effect of treatments in successive years.

All sprays were applied with a power sprayer and a single-nozzle gun, using a pressure of about 125 pounds. The operator went under the branches of each tree and sprayed the trunk and each branch from at least four positions to insure thorough coverage. The branches were sprayed as far up as rough bark occurred. The amount of spray used varied from 1.25 to 2 gallons per tree, depending upon the size of the tree and the number of large branches.

Preliminary examinations of some of the

[1] EPN-300.

Table 2.—Results of spraying for the control of the pear borer on apple trees, Waynesboro, Virginia, 1951.

Materials per 100 Gallons	Dates Applied	Reduction in Infestation		Reduction in Moth Emergence
		Larvae		
		Large	Small	
Parathion, 15%				
2 lbs.	May 15, 28, June 15	49%	97%	46%
3 lbs.	May 28	38	97	60
3 lbs.	May 28, June 15	50	99	
5 lbs.	May 15	58	92	
5 lbs.	May 28	63	98	
5 lbs.	May 28, June 15	78	99	82
5 lbs.	June 15	35	95	55
5 lbs.	July 3	26	92	
EPN 300				
2 lbs.	May 28	11	95	
2 lbs.	May 28, June 15	53	98	
2 lbs.	June 15	13	95	
3 lbs.	May 28	45	96	
3 lbs.	May 28, June 15	68	99	
3 lbs.	June 15	29	96	
3 lbs.	July 3	10	91	
DDT, 50%				
2 lbs.	May 15, 28, June 15	9	31	55
5 lbs.	May 28, June 15	46	98	75
8 lbs.	May 28, June 15	61	99	
8 lbs.	July 3	0	88	
Borers per check tree		58	130	
Moth emergence per check tree				201

sprayed trees were made in July and August, but the data presented here except for those on moth emergence, were obtained in examinations made late in September and in October each year. Each tree was scraped carefully, the burrows of the pear borers opened, and the size and condition of each larva noted. From the size of each larva an estimate was made of the time of its hatching. Those larvae which were in the second year of their growth were classed as "large", the others as "small", as indicated in the tables. The large larvae had been in the trees for a period of about 16 months, the small ones for 4 or 5 months. The branches above 7.5 feet from the ground were excluded from the examinations because of the possibility that some of the higher infested areas might have been missed in spraying. Four trees were examined for each treatment in 1950, and five in 1951.

In 1951 some of the sprayed trees were examined in July and the cast pupal skins were removed and counted to determine the number of pear-borer moths that had emerged from each tree.

RESULTS.—Apple trees which had been sprayed with parathion and DDT on April 29, 1950, were examined about 2 weeks later to determine the effect of these sprays on the borers in the bark at the time of spraying. No appreciable mortality had resulted from these treatments during that period.

The results of the sprays applied May 25 and June 13, 1950, are presented in table 1. All of these sprays were more effective against the smaller larvae, or the new infestation, than against the large larvae, those that were in the bark or cambium when the sprays were applied. The reduction in new infestation may have resulted from the killing of the ovipositing moths, the killing of the newly hatched larvae, or both. Both the parathion spray applied May 25 and that applied June 13 were very effective against new infestation. Good control of large larvae was obtained on trees receiving both of these sprays. DDT gave fair control of new infestation, but was not very effective against existing infestation.

The results of the 1951 sprays are shown in table 2. The heavier applications of DDT and parathion gave results similar to those obtained in 1950, although the control was slightly lower. Good control of new infestation was obtained with three sprays containing 2 pounds of 15 per cent parathion, with one spray containing 3 pounds of 15 per cent parathion or 2 pounds of 25 per cent ethyl p-nitrophenyl thionobenzene-phosphonate and with two sprays containing 5 pounds of 50 per cent DDT. Fair control of existing infestation was obtained with two sprays containing 5 pounds of parathion or 3 pounds of the p-nitrophenyl compound. DDT sprays were not effective against existing infestation, as they failed to give a good kill of the large larvae in the burrows. Parathion and the p-nitrophenyl sprays applied on June 15 were generally more effective than those applied on May 28 or July 3. Reduction in moth emergence from the trees resulted from all sprays for which counts were made, table 2.

Table 3.—Results of treatments in 2 successive years for the control of the pear borer on apple trees, Staunton, Virginia, 1950–1951.

MATERIALS PER 100 GALLONS	APPLICATIONS EACH YEAR[1]	PER CENT REDUCTION IN INFESTATION OCTOBER 1951
Parathion, 25%, 3 lbs. 15%, 5 lbs.	2 in 1950 1 in 1951	96
Parathion, 15%, 5 lbs.	2 in 1950 none in 1951	60
DDT, 50%, 8 lbs.	2 in 1950 1 in 1951	83
DDT, 50%, 8 lbs.	2 in 1950 none in 1951	37
Trees thoroughly scraped[2]	Once in 1950	80
Number of borers per check tree—113		

[1] The 1950 sprays were applied May 25 and June 13; the 1951 spray was applied June 16.
[2] These trees were scraped in October 1950.

The results of spraying 2 years in succession are shown in table 3. Trees sprayed with parathion twice in 1950 and once in 1951 had only four borers per tree, compared with 113 per tree in those not sprayed at all. Trees sprayed both years with DDT had 19 borers per tree. Trees which had been thoroughly scraped in the fall of 1950 had a lower borer infestation than the trees which had been sprayed only in 1950.

SUMMARY AND CONCLUSIONS.—Good control of new infestation by the pear borer in apple trees can be obtained by the use of three sprays containing parathion at the rate of 2 pounds of 15 per cent wettable powder per 100 gallons applied

during the flight period of the moths. One spray containing 3 pounds of parathion or 2 pounds of the p-nitrophenyl compound and two sprays containing 5 pounds of 50 per cent DDT also gave good control of new infestation.

Fair control of existing infestation, resulting in reduced oviposition in the current and following season can be obtained by the use of two sprays containing 5 pounds of parathion or 3 pounds of the p-nitrophenyl compound applied during the flight period of the moths. Single sprays did not give effective control of existing infestation.

Effective control of the pear borer under conditions of heavy infestation cannot be obtained by spraying one year only, because of the two-year life cycle of a part of the borers. Under such conditions a spray containing 5 pounds of 15 per cent parthion or 3 pounds of the p-nitrophenyl preparation should be applied late in May or early in June two years in succession; or two sprays containing 3 pounds of parathion or 2 pounds of p-nitrophenyl compound should be applied late in May and in mid-June 2 years in succession. The addition of 2 pounds of parathion to three sprays in the regular schedule, beginning with the petal-fall application, followed 2 years in succession will be very effective in reducing heavy infestations. Particular attention must be given to the thorough wetting of all of the larger branches and the trunks of the trees.

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A Comparative Study of Organic Insecticides for Control of Grape Berry Moth[1]

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The effectiveness of DDT for the control of the grape berry moth, *Polychrosis viteana* Clem., has been established by a number of workers, Fleming & Maines (1947), Taschenberg (1948, 1950) and Cox (1949), as well as by numerous growers in the Erie Grape Belt. Although DDT has been outstanding for the control of many grape insects the problem of spray residues on the harvested fruit have stimulated interest in other insecticides, as well as combinations of DDT and other chemicals, for control of the grape berry moth. Evaluations of some of the newer insecticides as well as concentrate sprays to combat the grape berry moth are reported in this paper.

METHODS AND MATERIALS.—The investigations were conducted in commercial vineyards planted to the variety Concord. The vines were trained to the umbrella system. The tests were performed only in vineyards that had been in previous years heavily infested with grape berry moth. During the seasons of 1949 and 1950 the test plots were four rows wide and 18 to 24 vines long. The test plots in 1951 were three rows wide and 30 vines long. In the vineyard where the concentrate sprays were tested the plots were 7 rows wide and 40 to 50 vines long. During the years 1949 and 1950 the plots were replicated four times and in 1951 they were replicated three times.

At harvest time ten count vines were selected at random from the inside rows of each plot. Ten clusters of grapes were taken from each of the ten vines and a record made of the number of clean and infested berries on each cluster. The results were converted to the per cent control, calculated according to the following formula:

$$\frac{100 \times A - B}{A} = \text{per cent control}$$

A = per cent infested berries on the untreated cluster.

B = pre cent infested berries on the treated cluster.

The sprays were applied with a conventional sprayer and a covered, inverted, U-shaped boom carrying seven nozzles

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on each side of the row and so arranged that the spray from the nozzles was directed upwards and into the foliage and clusters of the vine. From 200 to 225 gallons of spray materials were applied to the acre. The sprays were applied at a pressure ranging from 450 to 500 pounds per square inch. The concentrate sprays were applied with an air blast sprayer. With this machine the air was generated by a double 18 inch blower, driven at 3600 revolutions per minute, and each blower delivered 1200 to 1400 cubic feet of air per minute at an initial velocity of 200 miles per hour. However, this velocity dropped to approximately 90 miles per hour, 2 feet from the air outlet. The insecticide was introduced into the air stream through a flooding nozzle,[1] at a pressure of 90 pounds per square inch. This nozzle produced a flat spray at a 75° angle of deflection. Two fish tail air outlets directed the spray upwards and into the foliage and clusters of the vine.

The materials used in the experiments were as follows: a wettable powder containing 50 per cent and 75 per cent DDT; a paste containing 50 per cent DDT; a wettable powder[2] containing 50 per cent TDE; a wettable powder[3] containing 50 per cent methoxychlor; a wettable powder[4] containing 25 per cent 1,1-bis(p-fluorophenyl) 2,2,2-trichloroethane; a wettable powder[5] containing 25 and 50 per cent 1,1-bis(p-ethylphenyl) 2,2-dichloroethane; a wettable powder[6] containing 25 per cent S(1,2-bis(ethoxycarbonyl)ethyl) 0,0-dimethyl dithiophosphate; a wettable powder[7] containing 25 and 27 per cent ethyl p-nitrophenyl thionobenzenephosphonate; a wettable powder[8] containing 15 and 25 per cent parathion; an emulsifiable product[9] containing 50 per cent S(1,2-bis(ethoxycarbonyl)ethyl) 0,0-dimethyl dithiophosphate; an emulsifiable product[10] containing as active ingredient 33.4 per cent of a mixture of one part parathion and four parts methyl analogue of parathion, active ingredient designated as dialkyl nitroaryl thiophosphates; an oil[11] viscosity 53 seconds Saybolt at 100° F., unsulfonated residue 93 per cent; an emulsifying agent[12] containing pthalic anhydride of glycerol alkyl resin; an emulsifying agent[13] containing 85 per cent polyoxyethylene thioethers; copper sulphate, snow form of crystals; tri-basic copper sulphate, 26 per cent copper; hydrated lime, a high calcium hydrate; ferbam, 76 per cent ferric dimethyldithiocarbamate.

DISCUSSION AND RESULTS.—The results of the experiments in 1949 are shown in table 1. It is evident from the data that three applications of DDT will satisfactoriy control the grape berry moth when the rate of infestation is extreme. One application of DDT for the first brood and one for the second brood did not give a high degree of control. Parathion appears to be very effective against the grape berry moth. The control obtained with three sprays was as good as with four. A program of two applications of DDT for the first brood and one of parathion for the second brood gave excellent control. Sprays of TDE were less effective than DDT and parathion. In vineyard A during the season of 1950 split programs of DDT and parathion were compared with a straight schedule of DDT. The results are given in table 2. As may be seen in table 2, two applications of DDT for the first brood and one of parathion for the second brood was as effective against the grape berry moth as a full schedule of DDT. Excellent control was also obtained with DDT in the first application followed by parathion in the second and third sprays. The results of the tests in vineyard B are shown in table 3. Methoxychlor proved to be quite effective against the grape berry moth and three applications appear to be as effective as four. Parathion gave excellent control and three applications were as effective as four. A split schedule of methoxychlor and parathion gave satisfactory control. Sprays of TDE were less effective than parathion. As may be noted in tables 2 and 3, there was a light infestation of grape berry moth and this may have had some influence on the degree

[1] Tee-jet.
[2] *Rhothane*, Rhom and Haas Co., Philadelphia, Pa.
[3] *Marlate 50*, E. I. du Pont de Nemours and Co., Wilmington, Del.
[4] *Pen Flour*, Pennsylvania Salt Manufacturing Co., Philadelphia, Pa.=TM-4.
[5] *Q-137*, Rhom and Haas Co., Philadelphia, Pa.=TM-5.
[6] *4049*, American Cyanamid Co., New York, N. Y.=TM-6.
[7] *EPN-300*, E. I. du Pont de Nemours and Co., Wilmington, Del.=TM-7.
[8] *Thiophos 3422*, American Cyanamid Co., New York, N. Y. =TM-8.
[9] *4049*, American Cyanamid Co., New York, N. Y.=TM-9.
[10] *Metacide*, Geary Chemical Co., New York, N. Y.=TM-10.
[11] *Gulf Oil 501*, Gulf Oil Corp., Pittsburgh, Pa.=Oil, TM-11.
[12] *Triton B-1956*, Rhom and Haas Co., Philadelphia, Pa. =Emulsifier-1.
[13] *Steroz-6*, Monsanto Chemical Co., St. Louis, Mo.=Emulsifier-2.

Table 1.—Results of experiments for grape berry moth, 1949.

MATERIAL[1] AND AMOUNTS PER 100 GALLONS	APPLICATIONS	PER CENT	
		Infested Berries	Control
50% DDT, 1.5 lbs.	1, 2, & 3	0.51	98.7
50% DDT, 1.5 lbs.	1, & 3	2.38	93.9
50% DDT, 1.5 lbs. 25% parathion, 1 lb.	1, 2 & 3	0.94	97.5
25% parathion, 1 lb.	1, 2, & 3	0.52	98.7
25% parathion, 1 lb.	1, 2, 3, & 4	0.15	99.6
50% TDE, 1.5 lbs.	1, 2, & 3	3.34	91.4
Check, no spray		39.3	—

[1] Bordeaux mixture 2-2-100 was used in all the treatments in the first, second, third and fourth applications. Also one quart of miscible oil (oil 9 parts and 1 part of Emulsifier 1). Spray dates: first application June 20, second application June 30, third application July 27 and the fourth application August 4.

Table 3.—Results of experiments for grape berry moth in vineyard B. 1950.

MATERIAL[1] AND AMOUNTS PER 100 GALLONS	APPLICATIONS	PER CENT	
		Infested Berries	Control
50% methoxychlor, 2 lbs.	1, 2, 3, & 4	0.3	97.8
50% methoxychlor, 2 lbs.	1, 2, & 4	0.2	98.5
50% methoxychlor, 2 lbs. 25% parathion, 1 lb.	1, & 2, 3	0.2	98.5
25% parathion, 1 lb.	1, 2, 3, & 4	0.1	99.2
25% parathion, 1 lb.	1, 2, & 3	0.3	97.8
50% TDE, 2 lbs.	1, 2, & 3	1.0	92.6
Check, no spray		13.7	—

[1] Bordeaux mixture 2-2-100 was used in all the treatments in the first, second, third and fourth applications. Also one quart of miscible oil (oil 9 parts and 1 part of Emulsifier 1). Spray dates: first application June 30, second application July 11, third application August 16 and fourth application August 23.

of control obtained with some of the insecticides.

In vineyard C some organic phosphate insecticides, as well as TM-1 (1,1-bis(p-fluorophenyl) 2,2,2-trichloroethane and 1,1-bis(p-ethylphenyl) 2,2-dichloroethane) were tested against the grape berry moth. The results in table 4 indicate that ethyl p-nitrophenyl thionobenzenephosphonate (TM-7) and dialkyl nitroaryl thiophosphates are quite toxic to grape berry moth. Even with a light infestation, sprays of S(1,2-bis(ethoxycarbonyl)ethyl) 0,0-dimethyl dithiophosphate, 1,1-bis(p-fluorophenyl)2,2,2-trichloroethane (TM-4) and 1,1-bis(p-ethylphenyl) 2,2-dichloroethane (TM-5) did not give a satisfactory degree of control. During the season of 1950 sprays of dialkyl nitroaryl thiophosphates injured the fruit and foliage of Concord grape.

In 1951 tests were conducted in vineyards A and B. The results in vineyard A are shown in table 5. The data indicates that ethyl p-nitrophenyl thionobenzenephosphonate (TM-7) is as effective against the grape berry moth as DDT and parathion. A schedule of two sprays of DDT for the first brood and one spray of parathion for the second brood gave satisfactory control. Sprays of 1,1-bis(p-ethylphenyl) 2,2-dichloroethane and S(1,2-bis-(ethoxycarbonyl)ethyl) 0,0-dimethyl dithiophosphate were less effective than DDT. With a severe infestation methoxychlor was less effective than DDT.

In vineyard C concentrate sprays of DDT, methoxychlor and parathion were tested against the grape berry moth. All the treatments received three applications of spray. A list of the treatments and the results are shown in table 6. In the experiments parathion, methoxychlor and 50 per cent DDT wettable powder and paste were used at four times the normal concentration. A 75 per cent DDT wettable powder was used at six times the normal concentration. It is evident from the data in table 6 that concentrate sprays of DDT, methoxychlor and parathion were quite effective against the grape berry moth. However, further tests will

Table 2.—Results of experiments for grape berry moth in vineyard A. 1950.

MATERIAL[1] AND AMOUNTS PER 100 GALLONS	APPLICATIONS	PER CENT	
		Infested Berries	Control
50% DDT, 1.5 lbs.	1, 2, & 3	0.4	97.0
50% DDT, 1.5 lbs. 25% parathion, 1 lb.	1, & 2 & 3	0.4	97.0
50% DDT, 1.5 lbs. 25% parathion, 1 lb.	1 & 2 & 3	0.1	99.2
Check, no spray		13.4	—

[1] Bordeaux mixture 2-2-100 was used in all the treatments in the first, second and third applications. Also one quart of miscible oil (oil 9 parts and 1 part Emulsifier 1. Spray dates: first application June 30, second application July 11 and the third application August 16.

Table 4.—Results of experiments for grape berry moth in vineyard C. 1950.

MATERIAL[1] AND AMOUNTS PER 100 GALLONS	APPLICATIONS	PER CENT	
		Infested Berries	Control
TM-6 1 pt.	1, 2 & 3	2.5	78.6
25% TM-6 2 lbs.	1, 2 & 3	2.6	77.7
25% TM-4 1.5 lbs.	1, 2 & 3	1.4	88.0
50% TM-5 2 lbs.	1, 2 & 3	1.0	91.0
TM-10 (33.4% emulsion), 1 pt.	1, 2 & 3	0.5	95.7
27% TM-7 1 lb.	1, 2 & 3	0.2	98.3
Check, no spray		11.7	—

[1] Bordeaux mixture 2-2-100 was used in all the treatments except No. 1. In test No. 1 ferbam was used at the rate of 1.5 lbs. to 100 gallons. Also one quart of miscible oil (oil 9 parts and 1 part of TM-1). Spray dates: first application June 28, second application July 7 and third application August 17.

Table 5.—Results of experiments for grape berry moth in vineyard A. 1951.

Material[1] and Amounts per 100 Gallons	Applications	Per Cent	
		Infested Berries	Control
50% DDT, 1.5 lbs.	1, 2, & 3	0.92	97.3
50% DDT, 1.5 lbs.			
15% parathion, 1.5 lbs.	1, & 2, 3	1.13	96.7
15% parathion, 1.5 lbs.	1, 2, & 3	1.18	96.6
50% methoxychlor, 2 lbs.	1, & 2,	1.08	96.9
15% parathion, 1.5 lbs.	3		
50% methoxychlor, 2 lbs.	1, 2, & 3	1.66	95.2
25% TM-7, 1 lb.	1, 2, & 3	0.89	97.4
25% TM-9, 3 lbs.	1, 2, & 3	1.93	94.4
25% TM-5, 3 lbs.	1, 2, & 3	2.87	91.6
Check, no spray		34.4	—

[1] Bordeaux mixture 2-2-100 was used in all the treatments in the first, second and third applications. Also one quart of miscible oil (oil 9 parts and 1 part of Emulsifier 1). Spray dates: first application June 25, second application July 6 and the third application August 10.

Table 6.—Results of concentrate sprays for control of the grape berry moth in vineyard B. 1951.

Material[1] and Amounts per 100 Gallons	Concentration ×Normal	Gallons per Acre	Per Cent	
			Infested Berries	Control
50% DDT (paste), 6 lbs.	4	50–60	0.54	97.4
50% methoxychlor, 8 lbs.	4	50–60	0.67	96.7
75% DDT, 6 lbs.	6	30–40	0.57	97.2
50% DDT, 6 lbs.	4	50–60	0.47	97.7
15% parathion, 6 lbs.	4	50–60	0.12	99.4
Check, no spray			20.8	—

[1] In the first and second applications ferbam was used at 6 pounds to 100 gallons. In the third application 26 per cent tribasic copper sulphate was used at 12 pounds to 100 gallons and 12 pounds of hydrated lime. Also one pint of miscible oil (oil 8 parts and 2 parts emulsifier). Spray dates: first application June 26, second application July 7 and the third application August 14.

be necessary in vineyards where the infestation is quite severe to finally establish the value of concentrate sprays for the control of grape berry moth.

SUMMARY.—Field experiments during the seasons of 1949, 1950 and 1951 were conducted in vineyards comparing DDT and other organic insecticides for the control of grape berry moth. Three applications of DDT, at the rate of 12 ounces to 100 gallons, gave excellent control. Three sprays of parathion, used at the rate of 4 ounces to 100 gallons, was very effective against the grape berry moth. A program of two sprays of DDT for the first brood and one application of parathion for the second brood gave a satisfactory degree of control. Ethyl p-nitrophenyl thionobenzenephosphonate, at the rate of 0.25 pound to 100 gallons, was quite toxic to the grape berry moth. Methoxychlor in severely infested vineyards was slightly less effective than DDT. Sprays of TDE, 1,1-bis(p-ethylphenyl) 2,2-dichloroethane (TM-5) and S(1,2-bis(ethoxycarbonyl)ethyl) 0,0-dimethyl dithiophosphate (TM-6) were less effective than DDT and parathion against the grape berry moth. Experiments for one season indicate that concentrate sprays of DDT, parathion and methoxychlor are quite effective for the control of the grape berry moth.

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Control of Corn Earworm in Sweet Corn in Alabama

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The development of the oil injection method by Barber (1938) for control of the corn earworm, *Heliothis armigera* (Hbn.), in corn opened a new field of investigation. Research by entomologists too numerous to list in this paper led to the ultimate development of DDT-mineral oil emulsion sprays recommended by Blanchard, *et al.* (1950). Experiments were conducted with DDT-mineral oil emulsions on control of corn earworm in Alabama in 1950 and 1951. Results of these experiments are given here.

EXPERIMENT AT FAIRHOPE, 1950.—An experiment was conducted with DDT-mineral oil emulsion sprays to determine the effectiveness of 10 and 20 pounds of mineral oil with 2 pounds of DDT per acre per application and to determine the number of applications necessary for earworm control. The treatments were replicated 4 times in a randomized block design. Plots consisted of four rows of sweet corn 60 feet long with no borders between plots. The sprays were applied with a cone nozzle on a knapsack sprayer at the rate of 30 gallons of spray per acre. The insecticides were applied to both sides of the row in a continuous spray directed at the ears to simulate mechanical application. The first spray was applied on May 24, when 56 per cent of the ears were showing silk. Subsequent applications were made at 3-day intervals. Record ears were harvested from the two inside rows. Two harvests were made, June 8 and June 13.

The results of the experiment are presented in table 1. The infestation on untreated plots averaged 94 per cent. Significant control of the earworm was achieved with all sprays tested. There was no significant difference between applications of 10 and 20 pounds of mineral oil with 2 pounds of DDT per application, the infestations being 12.2 and 9.3 per cent, respectively. Three applications of 20 pounds of oil and 2 pounds of DDT per acre gave better control than two, which in turn gave better than one application. It was apparent that all of the sprays reduced the yield of roasting ears. The untreated plots averaged over 13,000 ears per acre, while the highest yield on treated plots was only 11,592. However, all sprayed areas produced much higher yields of worm-free ears than did the unsprayed plots. The insecticidal treatments had no effect on the weight of the ears nor on how well they were filled out. The plots that received 20 pounds of oil per acre per application showed considerable foliage burn; those receiving 10 pounds had considerably less burn.

EXPERIMENT AT TALLASSEE, 1950.—This test compared the effectiveness of rates of mineral oil when used with 2 pounds of DDT per acre per application. The experiment involved four treatments, which were replicated four times in a randomized block design. The plots consisted of four rows 90 feet long. There were four buffer rows between plots. Each plot was sprayed at 100 pounds pressure with two fan nozzles per row on a high-clearance, self-propelled sprayer. The spray was directed at the ears and was applied at the rate of 17.5 gallons per acre. The first spray was applied on July 1, when 68 per cent of the stalks were showing silk. Two subsequent applications were made at 3-day intervals. Harvests were made on the two inside rows of each plot on July 11 and 19.

The results of the experiment are given in table 2. The infestation averaged 75 per cent on the untreated plots. All insecticidal treatments significantly reduced earworm infestation. There were no significant differences between the controls obtained from 0, 10, and 20 pounds of mineral oil when used with 2 pounds of DDT per acre per application. There was no apparent foliage burn and no difference in yield of roasting ears between treated and untreated plots.

EXPERIMENTS IN 1951.—Several experiments were conducted in 1951 at the Gulf Coast Substation and on the Corte Farm in Baldwin County. The sprays were all applied at 125 pounds pressure with a self-propelled high-clearance sprayer.[1] In each test the plots consisted of four rows across a 40-acre field. Each treatment in each test was replicated 4 times. All plots in each test,

[1] The sprayer was loaned to the Department of Zoology-Entomology by the John Bean Company.

Table 1.—Effect of DDT-mineral oil emulsion sprays on control of corn earworm in sweet corn. Fairhope, 1950.

Treatment	Ears Damaged by Worms	Ears per Acre	No. Worm-free Ears per Acre	Weight per Ear, Grams	Ears Filled out with Kernels
None	94.3%	13,196	755	182.0	89.5%
2 lb. DDT, 10 lb. mineral oil per acre, 3 applications	12.2	11,229	9,863	183.1	93.3
2 lb. DDT, 20 lb. mineral oil per acre; 3 applications	9.3	11,157	10,070	178.0	92.0
2 lb. DDT, 20 lb. mineral oil per acre; 2 applications	18.5	11,592	9,449	178.6	92.8
2 lb. DDT, 20 lb. mineral oil per acre; 1 application	48.5	11,022	5,641	184.8	92.6
LSD, 5% level	5.8	1,110	784	no difference	no difference

except the one on number of applications, received four applications at 3-day intervals beginning on June 22 when 10 per cent of the stalks were showing silk. The results were measured by harvesting and examining 100 ears taken at random from each plot. Only one harvest was made, July 10, because that is the practice followed by commercial sweet corn growers in Alabama.

Experiment 1. This experiment was designed to compare the effects of different volumes of spray, numbers of nozzles per row, types of nozzles, and speeds of the spraying machine on control of the corn earworm in sweet corn with DDT-mineral oil emulsions. The test involved seven treatments. A proprietary DDT-mineral oil emulsion[1] was used at the rate of 3 gallons per acre per application. This rate amounted to 2.4 pounds of DDT and 12.9 pounds of mineral oil per acre per application. The machine travelled approximately 4 miles per hour in low speed and approximately 8 miles per hour at high speed.

The results are presented in table 3. All spray treatments significantly reduced the infestation. There were no differences between the controls achieved with 12.5, 25, or 50 gallons of spray per acre. There was no difference between the controls obtained with high and low speeds of the machinery. There was no difference between the controls resulting from use of fan and cone nozzles or between those put on with two and four fan-type nozzles per row.

Experiment 2. The purpose of this test was to determine the optimum number of applications of spray necessary for practical control of the earworm. Three, four, five and six applications were compared. All treatments were begun at the same time, except on the plots receiving six applications, the first of which was applied as a pre-silk spray 3 days before spraying was begun on the other plots.

[1] Thompson-Hayward WE-5, which contains 0.8 lb. of DDT and 4.3 lb. of mineral oil per gallon.

Table 2.—Effect of DDT-mineral oil emulsion sprays on control of corn earworm in sweet corn. Tallassee, 1950.

Treatment	Ears Damaged by Worms	Ears per Acre	Worm-free Ears per Acre
None	75.0%	5430	1380
10 lb. oil, 2 lb. DDT per acre; 3 applications	28.2	6558	4722
20 lb. oil, 2 lb. DDT per acre; 3 applications	26.2	5700	4170
No oil, 2 lb. DDT per acre; 3 applications	31.2	5688	3720
LSD, 5% level	13.5	no difference	1056

Table 3.—Effect of different gallonages of spray, types of nozzle, number of nozzles per row, and speeds of sprayer on control of corn earworm in sweet corn with DDT-mineral oil emulsion.[1] Corte Farm, 1951.

Treatment	Worm-free Ears	Angle
None	37%	37.3
12.5 gal./A; 4 fan-type nozzles/row; low speed	95	77.6
25 gal./A; 4 fan-type nozzles/row; low speed	98	82.2
50 gal./A; 4 fan-type nozzles/row; low speed	99	83.9
25 gal./A; 4 fan-type nozzles/row; high speed	98	84.4
25 gal./A; 4 cone-type nozzles row; low speed	98	83.0
25 gal./A; 2 fan-type nozzles/row; low speed	98	83.6
LSD, 5% level	—	8.2

[1] Thompson-Hayward WE-5 Corn Earworm Spray 3 gallons per acre, which amounted to 2.4 pounds of DDT and 12.9 pounds of mineral oil per acre per application.

Table 4.—Effect of number of applications of DDT-mineral oil emulsion sprays[1] on control of the corn earworm in sweet corn. Corte Farm, 1951.

TREATMENT[2]	WORM-FREE EARS	ANGLE
3 applications	77 %	61.55
4 applications	94.5	76.72
5 applications	96.5	80.97
6 applications	96.0	80.47
LSD, 5% level	—	7.2

[1] Kornol, produced by Florida Agricultural Supply Co., which contains 0.4 lb. of DDT and 5.6 lbs. of mineral oil per gallon, was used at the rate of 3 gallons per acre per application.
[2] All sprays were applied at 3-day intervals beginning when 10 per cent of the stalks were showing silk except plots receiving 6 sprays, the first of which was a pre-silk spray.

A proprietary DDT-mineral oil emulsion spray was used to give 1.2 pounds of DDT and 16.8 pounds of mineral oil per acre per application in 25 gallons of spray.

The results are given in table 4. There were no differences between the controls resulting from four, five, or six applications. All of them gave significantly higher percentages of worm-free ears than three applications, which resulted in only 77 per cent worm-free ears. This percentage is too low for practical control.

Experiment 3. This experiment was conducted to determine the effect of varying the amount of DDT per acre when the amount of mineral oil remained constant. A commercial 25-per cent emulsifiable DDT concentrate in a xylene base and a commercial white mineral oil, with a Saybolt viscosity of 70 to 78 seconds, were used. Two per cent by volume of emulsifier was added to the mineral oil. The DDT was applied at 0, 0.5, 1.0, and 2.0 pounds per acre per application with 10 pounds of mineral oil in 25 gallons of spray.

The results are presented in table 5. The degree of control increased significantly as the DDT was increased up to 2 pounds per acre. For practical control 2 pounds per acre per application for four applications was required.

Experiment 4. This experiment was set up to determine the effect of varying the amount of mineral oil in DDT-mineral oil emulsions on control of the corn earworm. The same sources of materials were used in this experiment as in Experiment 3 designed to determine rate of DDT per acre. Oil was used at the rates

Table 5.—Effect of varying rates of DDT in DDT-mineral oil emulsions on control of corn earworm in sweet corn. Corte Farm, 1951.

TREATMENT[1]	WORM-FREE EARS	ANGLE
No DDT; no mineral oil	19.0%	25.15
No DDT; 10 lb. mineral oil	32.5	34.45
0.5 lb. DDT; 10 lb. mineral oil	53.5	47.00
1.0 lb. DDT; 10 lb. mineral oil	77.5	61.70
2.0 lb. DDT; 10 lb. mineral oil	89.0	70.70
LSD, 5% level	—	8.02

[1] Indicated amounts were applied per acre per application for 4 applications beginning when 10 per cent of the stalks were showing silk.

of 5, and 20 pounds per acre per application with 2 pounds of DDT, or was omitted.

The results are given in table 6. All of the insecticidal treatments significantly reduced the earworm infestation below that in the unsprayed plots. However, there was no significant difference between any of controls obtained by the spray treatments. The 2 pounds of DDT with no mineral oil gave as good control as it did with 5 or 20 pounds of oil per acre per application.

SUMMARY.—Experiments on control of corn earworm, *Heliothis armigera* (Hbn.), were conducted in Alabama during 1950 and 1951.

DDT-mineral oil emulsions gave excellent control of the corn earworm in sweet corn, whether applied by knapsack sprayer or by power-driven machinery. Three applications of 10 or 20 pounds of mineral oil with 2 pounds of DDT per acre per application with a knapsack sprayer gave

Table 6.—Effect of varying rates of mineral oil in DDT-mineral oil emulsions on control of corn earworm in sweet corn. Corte Farm, 1951.

TREATMENT[1]	WORM-FREE EARS	ANGLE
None	19.0%	25.15
No oil; 2 lb. DDT	97.5	83.85
5 lb. oil; 2 lb. DDT	96.8	82.68
20 lb. oil; 2 lb. DDT	97.5	82.40
LSD, 5% level	—	9.55

[1] Indicated amounts were applied per acre per application for 4 applications beginning when 10 per cent of the stalks were showing silk.

good control of the earworm. However, application with a knapsack sprayer reduced the total yield and caused some foliage burns. The treatments had no effect on the weight of the ears or on how well they were filled out at the tips. The same treatments applied at 100 pounds pressure with a high-clearance power-driven sprayer caused no foliage burn or yield reduction.

There were no significant differences between the controls resulting from the use of 12.5, 25, or 50 gallons of spray per acre as long as the rate of toxicants per acre remained constant. The ground speed of the machinery had no effect on control when volumes and rates of toxicants were the same. There was no difference in the controls obtained with fan and cone nozzles nor with two and four fan-type nozzles per row. When only one harvest of sweet corn was made, as is the custom with commercial growers in Alabama, four applications of spray were necessary to give practical control.

In the test on amount of DDT in DDT-mineral oil[1] emulsions, 2 pounds of DDT per acre per application was necessary to give 90 per cent control. Two pounds of DDT per acre per application in an emulsion spray gave as good control with no mineral oil as it did when applied with 5 or 20 pounds of mineral oil.

[1] *Kornol*, produced by the Florida Agricultural Supply Co., which contains 0.4 lb. of DDT and 5.6 lbs. of mineral oil per gallon.

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The Effect of DDT on Mite and Predator Populations in Apple Orchards

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This paper summarizes the results of the second year of a study begun in 1947 to determine the effect on phytophagous mites and their predators of DDT sprays applied for codling moth control in Virginia apple orchards. Preliminary results obtained during the first season were briefly discussed in an earlier paper (Clancy & Pollard 1948).

The studies were considerably expanded in 1948 to include 15 highly productive commercial orchards, 4 somewhat neglected orchards, referred to as marginal, and 6 abandoned orchards. In the commercial orchards sprays containing DDT, lead arsenate, or a combination of both materials, were applied by the various growers more or less as called for in standard spray schedules. In each orchard either a DDT or a lead arsenate check block was provided for comparative studies. Since DDT was used by most of the growers, the check blocks usually consisted of 25 to 50 or more trees sprayed with lead arsenate instead of DDT.

Only the regular dormant- and blossom-period applications, which did not include DDT, were made in the marginal orchards, because of a late freeze that destroyed their crops. In previous years those orchards had been sprayed regularly. The trees in the abandoned orchards had reverted to a wild state and no longer produced edible fruit. They had not been sprayed for several years. Studies in the abandoned orchards had to be discontinued at the end of August because of the poor condition of the foliage.

Mite and predator populations were sampled by methods previously described (Clancy & Pollard 1948), but the size of samples was reduced to 100 leaves and the orchard-predator counts to observations lasting one-half hour at the time of each visit. Ten leaves of intermediate age and size were collected around the periphery of each of 10 trees and were placed in 1-pint ice-cream cartons. These were taken to the laboratory, where the leaves were brushed (method of Henderson & McBurnie 1943) and their mite and predator contents were recorded. The authors also spent about three minutes examining the foliage from the inside of each sample

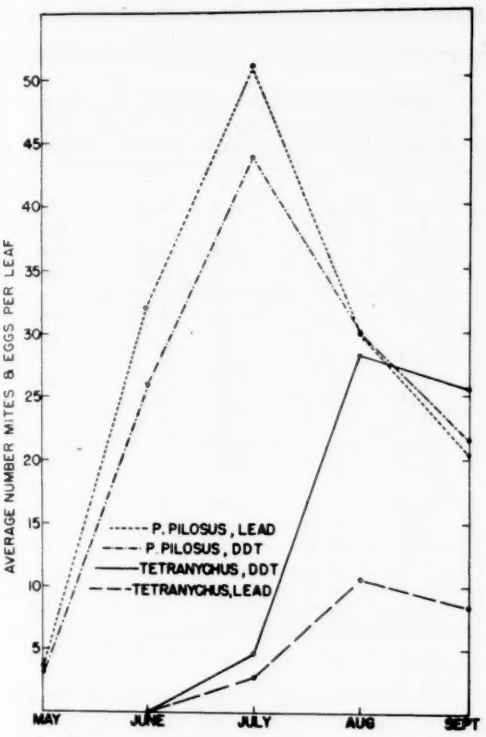

FIG. 1.—Phytophagous-mite populations in DDT- and lead arsenate-sprayed blocks of commercial apple orchards.

tree, to record the larger and more active predators not generally obtained by brushing. Although data recorded by the orchard predator counts are not directly comparable with those obtained by brushing, both methods are essential for a representation of the total predator population, and the figures were therefore combined for purposes of comparative study.

COMMERCIAL ORCHARDS.—Major attention was devoted to an extensive survey of mite and predator populations in DDT- and lead arsenate-sprayed blocks in commercial orchards located in an area extending from Clarke and Frederick Counties, in northern Virginia, south to Botetourt County. The central Virginia orchards were sampled about every two weeks from May through September, whereas those in northern and southern Virginia were visited at monthly intervals beginning in June. These orchards received from 3 to 7 applications of DDT (generally 2 pounds of 50-per cent wettable powder per 100 gallons) from late in April throughout most of July. The lead arsenate check blocks were sprayed according to standard schedules.

In apple orchards in Virginia, populations of the European red mite, *Paratetranychus pilosus* (C. & F.), generally reach a peak in midsummer. The spider mites *Tetranychus* spp.[1] gradually move up from the ground cover and become most numerous late in the summer. These trends are well illustrated by the result of studies in the DDT- and lead arsenate-sprayed blocks in figure 1. Early-season red mite populations were consistently higher in the lead arsenate blocks during the observation period, apparently because of the mild acaricidal effect of DDT. Increases in the number of *Tetranychus* mites were much greater in the DDT blocks during August and September. Total counts for the entire season showed only about 10 per cent more mites in the DDT blocks than in the lead arsenate blocks, and this was entirely the result of increases in *Tetranychus* spp. It is therefore evident that DDT failed to stimulate outbreaks of the European red mite during this period, as it often does in the Middle West and elsewhere, but it was responsible for higher spider mite populations. Similar increases of *Tetranychus* spp. on apple following the use of DDT have been noted by Chapman & Lienk (1950) and Dean (1950) in New York, Hough (1946) in Virginia, Newcomer & Dean (1946) in Washington, and Steiner *et al.* (1944) in Indiana.

The effect of DDT on mite predators in these same orchards is shown in figure 2. Early in the season predators were only slightly more numerous in the lead arsenate blocks than in the DDT blocks. They increased rapidly in the DDT blocks late in the summer, however, as residues deteriorated and *Tetranychus* populations increased. As a result of these increases there were actually about 50 per cent more predators during the entire season in the blocks where DDT had been used than in the lead arsenate blocks.

In these orchards the small coccinellid *Stethorus punctum* (Lec.) was by far the most numerous mite enemy, comprising 81 per cent of the total predator population, even though the adults are highly susceptible to DDT. The adults of this predator are very active and seldom re-

[1] Virginia populations consisted of both *Tetranychus bimaculatus* Harvey and *T. Schoenei* McGregory.

Table 1.—Mite and predator populations per 100 leaves and one-half hour tree counts in three types of Virginia Apple orchards, 1948.

Type of Orchard and Month	Average of Mites and Eggs		Total Predators	Average Number—Predators				Mites Per Predator
	Tetranychus	*P. Pilosus*		*Stethorus*	*Iphidulus*	Thrips	Others	
Commercial[1]								
May	0	343	4.5	4.0	0	0.3	0.2	76
June	8	3,197	4.6	2.4	0.1	.6	1.5	697
July	292	5,043	26.7	17.8	2.6	1.5	4.8	200
August	1,060	2,989	27.0	17.9	5.0	.9	3.2	150
Total	1,360	11,572	62.8	42.1	7.7	3.3	9.7	206
Marginal								
May	0	867	12.0	5.0	1.0	6.0	0	72
June	2	819	39.6	4.5	18.3	14.3	2.5	21
July	2	147	29.2	2.0	18.0	4.0	5.2	5
August	11	96	13.3	2.3	8.8	1.0	1.2	8
Total	15	1,929	94.1	13.8	46.1	25.3	8.9	21
Abandoned								
May	1	40	9.3	2.8	2.2	4.3	0	4
June	28	87	62.8	1.8	51.5	7.3	2.2	2
July	23	21	44.7	.7	42.0	.7	1.3	1
August	15	20	28.7	.5	27.5	0	.7	1
Total	67	168	145.5	5.8	123.2	12.3	4.2	2

[1] Lead arsenate blocks only, no DDT.

main for long or deposit many eggs in trees where mites are scarce. A close correlation was repeatedly observed between the abundance of *Stethorus* and that of its prey at various population levels. The large number of natural enemies in the DDT blocks was due entirely to the increase of *Stethorus*, following increases in the number of *Tetranychus* mites. Ninety-six per cent of all predators in these blocks were *Stethorus*. The effectiveness of *Stethorus* was apparently limited by its inability to attain controlling numbers until those of its prey had exceeded the economic level. Therefore its greatest benefit was in the reduction of late-summer and fall generations of mites.

Other enemies of lesser importance in the commercial orchards were the predaceous mite *Iphidulus* sp., the thrips *Leptothrips mali* (Fitch) and *Scolothrips sexmaculatus* (Perg.), the hemipterons *Iyaliodes harti* Knight, *H. vitripennis* var. *discoidalis* Reut., and *Orius insidiosus* (Say), and various Chrysopidae and Hemerobiidae. Unlike *Stethorus* these were consistently more numerous in the lead arsenate blocks although too few to be highly effective in mite control. *Iphidulus* sp. in particular, although the most numerous of these predators, was very scarce except late in the summer or in blocks where no DDT was used.

MARGINAL AND ABANDONED ORCHARDS COMPARED WITH COMMERCIAL ORCHARDS.—The observations made during 1948 in three different types of orchard are summarized in table 1.

A wide variation was evident in the abundance of the different predatory species in the commercial, marginal, and abandoned orchards, and also in the ratio of mites to predators. The well-cared-for commercial orchards, which received a full schedule of sprays, had the greatest number of mites per predator. The marginal orchards, which received only two early sprays, had an intermediate position. In the abandoned orchards there was an apparently favorable balance between mites and predators. In the marginal orchards the rapid transition toward a more favorable mite and predator balance soon after the discontinuance of spraying is also noteworthy. In the abandoned orchards *Iphidulus* was obviously the major predator, while *Stethorus* predominated in the commercial orchards which were heavily infested with phytophagous mites.

The unsprayed trees in the abandoned orchards were found to harbor a much greater number and variety of mite species,[1] including phytophagous, saprophytic, and predaceous forms, than trees in

[1] Identified by E. W. Baker, H. H. Keifer, and H. H. J. Nesbitt.

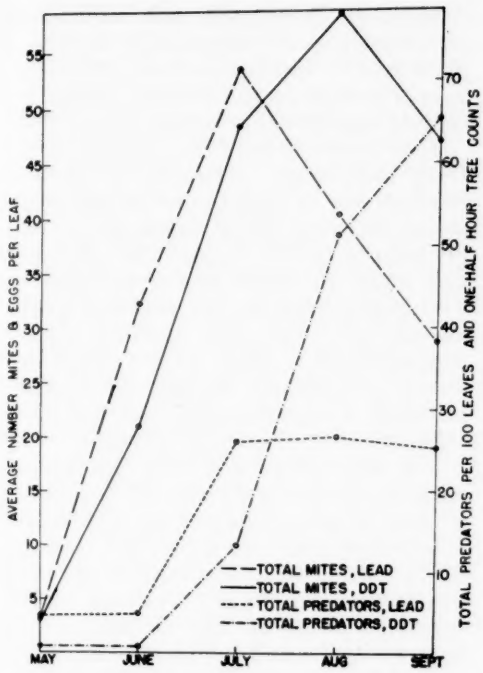

FIG. 2.—Mite and predator populations in DDT- and lead arsenate-sprayed blocks of commercial apple orchards.

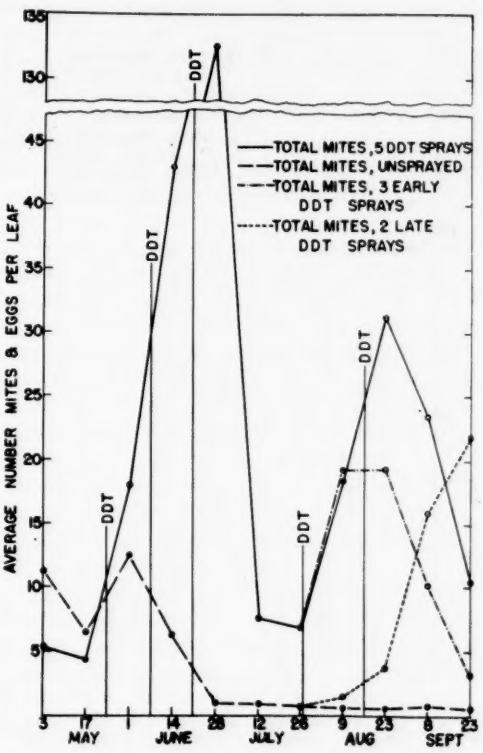

FIG. 3.—Effect of special DDT applications on the phytophagous-mite population in an unsprayed apple orchard.

the well-cared-for commercial orchards. The phytophagous group included *Tarsonemus* sp., *Bryobia praetiosa* Koch, and *Vasates schlectendali* (Nal.), the former being especially abundant and widespread. Other mites that were present—such as *Czenspinskia lordi* Nesbitt, *Oppia* sp., *Scheloribates* sp., *Oripoda elongata* Banks & Pergande, and an oribatid—are probably saprophytes and fungus feeders that normally occur under bark or in the soil. Only a few predaceous mites other than *Iphidulus* sp. were encountered, namely *Typhlodromus cucumeris* Oud., *Mediolata* sp., *Tydeus* sp., and *Pronematus* sp. Of these different kinds of mites only *Tarsonemus* sp. was found in appreciable numbers in the commercially sprayed orchards. On unsprayed trees *Iphidulus* may subsist in part on certain of these mites, thus accounting to some extent for the unusually high predator ratio shown in table 1.

The predaceous thrips were more numerous than *Stethorus* in the marginal and abandoned orchards, ranking next to *Iphidulus*, while the other predators (Hemiptera, Chrysopidae, etc.) seemed to be somewhat less numerous in the abandoned orchards than in the commercial or marginal orchards.

EFFECTIVENESS OF PREDATORS.—Although the data just presented seemed to indicate that *Iphidulus* was largely responsible for the low phytophagous-mite populations in unsprayed orchards, the generally low vigor and poor condition of the trees may also have been involved. Mites are known to reproduce more rapidly and attain higher levels of abundance on healthy foliage in vigorous growth than on foliage of unhealthy trees.

In further studies to determine more exactly the part played by *Iphidulus* in preventing increases of phytophagous mites, an experiment was arranged in one of the marginal orchards, in which the grower applied several DDT sprays to an isolated block of Red Delicious apples. Three early sprays were applied on May 24, June 8, and June 21 to 10 trees. Ten untreated trees were reserved as a check block. Two additional sprays were applied on July 27 and August 16 to five trees in each block, including the check, thus

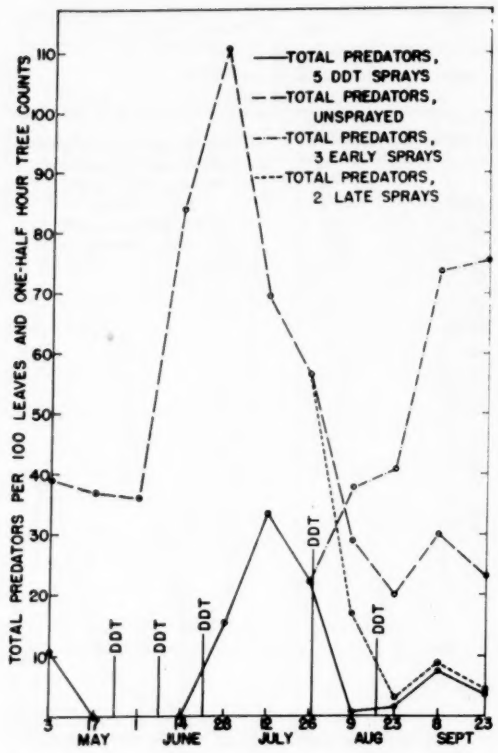

FIG. 4.—Effect of special DDT applications on the predator population in an unsprayed apple orchard.

creating four study plots with the following characteristics: Plot 1, 5 sprays; plot 2, unsprayed; plot 3, three early sprays; plot 4, two late sprays. The sprays contained from 12–24 ounces of actual DDT per 100 gallons. It was reasoned that if mites increased where the predators were killed by DDT and decreased in the adjoining unsprayed trees at the same time a rise in predator population was recorded, the predators would have demonstrated their effectiveness.

Figure 3 shows the relation between DDT and phytophagous-mite populations in each of these plots. Note especially the tremendous initial infestation and lesser secondary peak in the plot receiving five sprays, as compared with the declining infestation and subsequently very low population in the unsprayed trees. The rapid decrease in mite abundance between the third and fourth sprays may have been due to the accumulated feeding injury of the preceding generations (Henderson & Holloway 1942). The effect of both early and late sprays in stimulating mite increase is also clearly indicated.

Although *Tetranychus* spp. were again consistently more numerous in the DDT plots than in the others, most of the mites were *Paratetranychus pilosus*, which increased rapidly following the use of DDT.

The destruction of mite enemies by DDT is strikingly portrayed in figure 4. Furthermore, a direct correlations is apparent between DDT applications, low predator populations, and the phytophagous-mite increases shown in figure 3. The phytophagous-mite population was low and predators were abundant in the unsprayed plot. These data furnish evidence that natural enemies are, in fact, primarily responsible for the low mite infestations in unsprayed orchards.

The different predators in this experiment also varied according to the number of spray applications and the abundance of phytophagous mites, just and they did in the data presented in table 1. *Stethorus* predominated in the plot receiving 5 DDT sprays, whereas in the unsprayed plot both *Iphidulus* and the predaceous thrips outnumbered *Stethorus*. *Iphidulus* is undoubtedly the most effective predator, particularly at low host densities, but it does not seemable to survive the sprays presently used in commercial orchards. The lack of a winged adult stage prevents *Iphidulus* from escaping adverse influences and also retards its subsequent dispersal and build-up when conditions again become favorable.

DISCUSSION.—The important problem now before us is how best to encourage efficient mite predators in commercially sprayed orchards. On apples the problem is immensely complicated by the necessity for repeated applications of fungicides control apple scab and other diseases, and by the superiority of DDT over other materials for codling moth control.

Other workers have shown that sulfur is particularly harmful to a great many natural enemies, including predaceous mites (Cutright 1944; Flanders 1943; Garman & Townsend 1938; Lord 1947, 1949), and this material is still the main fungicide used on deciduous fruits. Most of our study orchards received from three to five applications of liquid lime-sulfur and elemental sulfur during April and May. *Iphidulus* was also extremely scarce at this season but increased gradually thereafter. Since *Iphidulus* was relatively ineffective, even in the lead arsenate

blocks, the sulfur may have been largely responsible for its failure. Certainly factors other than the use of DDT must have been involved.

In Nova Scotia the European red mite was apparently brought under control by *Iphidulus tilliae* (Oud.) when copper fungicides were used in place of sulfur (Lord 1949), and a considerable improvement was also noted with regard to codling moth infestation (Pickett 1949). Ullyett (1948) reports that modified spray programs have resulted in increased biological control of codling moth in South Africa. These and other recent studies on the coordination of biological with chemical control measures appear to offer considerable promise. However, as pointed out by Pickett (1949), the final answer can be obtained only through long-term ecological investigation which also includes the effect of such treatments on other species in the environment. Although the problems involved are necessarily complex and difficult of solution we cannot afford to overlook the possibilities suggested by this line of approach.

SUMMARY AND CONCLUSIONS.—Mite and predator populations were sampled at biweekly or monthly intervals in 25 commercial, marginal, and abandoned apple orchards in Virginia, to determine the effect on phytophagous mites and their natural enemies of DDT sprays applied for codling moth control.

In the well-cared-for commercial orchards, DDT failed to stimulate outbreaks of the European red mite more than did lead arsenate, possibly because of the depressing effect in both DDT and lead arsenate plots of sulfur fungicides on the dominant early-season predators. However, late-summer populations of the spider mites *Tetranychus bimaculatus* Harvey and *T. schoenei* McGregor definitely increased to higher levels in plots sprayed with DDT. Although the small coccinellid *Stethorus punctum* (Lec.) was the most important predator in these orchards, it was unable to attain controlling numbers until its prey had become abundant enough to cause definite injury. repardless of the material used in sprays. It was most numerous during August and September in the DDT blocks, after residues had deteriorated, preying largely on *Tetranychus* spp. Other enemies of lesser importance were the predaceous mite *Iphidulus* sp., the thrips *Leptothrips mali* (Fitch) and *Scolothrips sexmaculatus* (Perg.), and several Hemiptera, Chrysopidae, and Hemerobiidae.

In unsprayed orchards *Stethorus* was largely replaced by *Iphidulus* and the predaceous thrips. Mite populations were maintained at extremely low levels by the predators. When DDT was applied to several of these trees the predators were killed and infestations increased rapidly. *Iphidulus* is undoubtedly one of the most effective predators of phytophagous mites, particularly at low host densities, but it is unable to survive the sulphur and DDT sprays presently used in commercial orchards.

Long-term ecological studies are needed to determine whether biological control can be improved by modifying existing spray practices.

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Control of Sod Webworms in Southern California

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Sod webworms, also called lawn moths, are the most common insect pests of lawns in Southern California. The biology and habits of the two injurious species, *Crambus sperryellus* Klats and *Crambus bonifatellus* (Hulst), were described by Bohart (1947). Standard lead arsenate has been used to control sod webworms (Bohart 1947; Essig & Hoskins 1944; Jacobson *et al.* 1949; Matthysse 1949). Bohart also reported that pyrethrum, rotenone, and dichloroethyl ether were effective but that reinfestation was a serious problem with these materials since there is little residual effect. Experiments by R. H. Smith[2] (1945) and Ebeling *et al.* (1947) showed DDT to be a promising material. Matthysse (1949) recommends DDT, and Jacobson *et al.* (1949) recommend chlordane for sod webworm control. This paper gives the results of tests since 1947 with various insecticides for the control of *Crambus sperryellus* and *Crambus bonifatellus* in Southern California.

METHODS AND MATERIALS.—All of the experiments, unless otherwise indicated, were conducted on the Los Angeles campus of the University of California. Randomized blocks were used in 1947, 1948 and 1949, but in 1950 and 1951 large areas were treated with one or two materials. Infestations were checked both before and after treatment. Counts were on the basis of the number of larvae per square foot. A pyrethrum-rotenone solution was used to bring the larvae to the surface as suggested by Bohart (1947). After the post-treatment counts the check plots usually were treated with beta, beta′-dichloroethyl ether. This prevented the grass from being completely killed in the case of heavy infestations. Also, since the dichloroethyl ether would not prevent reinfestation, the residual effect of the insecticide treatments could be determined by comparing them with the checks.

All of the insecticides were applied as sprays with a small power sprayer. In 1947 and 1948 the sprays were applied with a spray gun at approximately 300 pounds pressure; in 1949, 1950 and 1951 a spray rod with a disc in the nozzle which threw a flat, fan-shaped spray was used, and in 1950 and 1951 the pressure was reduced to 150 to 200 pounds. Several types of hand equipment were also used in the 1949 tests. The grass was watered before treatment and was not watered again until necessary.

The insecticides used in the tests were wettable powders of DDT,[3] chlordane,[4] toxaphene,[5] aldrin and dieldrin,[6] and a chlordane emulsifiable concentrate.[7]

PRELIMINARY TESTS.—Preliminary tests in 1947 with DDT and toxaphene, and in 1948 with DDT, toxaphene and chlordane, indicated that all 3 materials would give effective control of sod webworms. The sprays contained 0.5 pound of active ingredient per 100 gallons and were applied at 0.5 gallon per square yard.

1949 TESTS.—More extensive experiments were conducted in 1949 following the establishment of an experimental turf project by the Division of Floriculture and Ornamental Horticulture. DDT, toxaphene and chlordane were tested at 5 and 10 pounds per acre, aldrin at 2.5 and dieldrin at 1.5 pounds per acre. The materials used per 100 gallons of spray were: DDT, 50 per cent wettable powder, 1 pound; toxaphene, 40 per cent wettable powder, 1.25 pounds; chlordane, 40 per cent wettable powder, 1.25 pounds; aldrin, 25 per cent wettable powder, 1

[1] Credit is due to R. J. Pence, John Gallagher and Richard Durbin for assistance in the 1947, 1950 and 1951 tests, respectively.
[2] Smith, R. H. 1945. Unpublished data on file in the Division of Entomology, University of California, Los Angeles.
[3] Furnished by the Geigy Co.
[4] Furnished by the Dow Chemical Co.
[5] Furnished in 1947 and 1948 by the Hercules Powder Co. and in 1949 and 1950 by the Chipman Chemical Co.
[6] Furnished by Julius Hyman and Co.
[7] Bandini Fertilizer Co.

pound; dieldrin, 15 per cent wettable powder, 1 pound.

There were 9 treatments replicated 7 times. Blocks I and II were Merion and Kentucky bluegrass, respectively. In blocks III to VI, each block was composed of 3 grass plots, each of which was divided into 3 spray plots. The grasses in these blocks were: III, C-1 Arlington bent, a mixture of C-1 Arlington, Astoria and Highland bents, and a mixture of Seaside, Astoria and Highland bents; IV, Astoria bent, Highland bent, Seaside bent; V, Illahee fescue, Ranier fescue, Chewings fescue; VI, Alta fescue, meadow fescue, Raritan velvet bent. These grasses were planted in a parkway in long narrow plots and were managed similar to golf course fairways. The size of the spray plots was 145 square feet. Block VII was Seaside bent and was managed similar to putting greens. This block was 15 feet wide and 90 feet long, and was divided into 9 spray plots of 150 square feet.

Pre-treatment counts were made in blocks I to VI on June 29 and averaged 5.6 larvae per square foot. Three counts were made in each type of grass and the infestation appeared to be fairly uniform throughout. In block VII the pre-treatment counts were made on July 1 and were 32, 16, 10 and 15 larvae per square foot for four counts. The infestation was heaviest at the west end where severe injury was already apparent.

One treatment was applied on June 29 and the remainder on July 5 and 6. Two counts were made in the check plot of block VII on July 6 and a third on July 8. There was an average of 27.3 larvae per square foot. The check plot was sprayed with dichloroethyl ether on July 10.

On July 19 and 20, 3 counts were made in each plot. No larvae were found in any of the treated plots while the check plots in blocks I to VI averaged 4.2 larvae per square foot. The plot that was treated with dichloroethyl ether on July 10 had an average 0.5 larvae per square foot.

While excellent control had been obtained with all materials, some of the plots in block VII were showing injury by September. The infestation varied with different plots but again it was heaviest in the west end. On September 6, four of the treated plots received a second application and the check plot was treated with dichloroethyl ether. In blocks I to VI a second application was not necessary.

Final counts were made on September 14 and 15. In blocks I to VI the check plots averaged 4.6 larvae per square foot while in the treated plots the number varied from 0.2 to 0.7 per square foot. In block VII no larvae were found in the plots sprayed on September 6, and only a few in those that had received a single application.

Two large plots of 1500 square feet each were also sprayed with DDT on July 7. The first plot was Seaside bent and 12 larvae were found in one pre-treatment count. The second plot was made up of small strips of various grasses and four pre-treatment counts averaged 16.5 larvae per square foot. Two pounds of 50 per cent wettable DDT was used to 100 gallons and applied at 2.7 and 2.6 pounds of actual DDT per acre to the 2 plots. On July 19, 3 counts in each plot showed an average of one larva per square foot in the first plot and no larvae in the second plot. Counts made on September 14 showed 1.3 and 2.7 larvae per square foot, respectively, in the two plots.

DDT, toxaphene and chlordane were also tested on several home lawns. The sprays contained 0.5 pound of the active ingredient per 100 gallons and were applied at 4.5 and 9.0 pounds of the active ingredient per acre. In addition, one lawn was treated with a spray containing 1 pound of actual toxaphene per 100 gallons applied at 4 pounds per care. The sprays were applied on June 8, 9, and 10 and excellent results were obtained. Pre-treatment counts had shown from 5 to 12.5 larvae per square foot, but none were found in counts made on July 21 and 22.

1950 TESTS.—In 1950 the bent grasses receiving greens management were showing injury by July. Pre-treatment counts averaged 12.5 larvae per square foot with the infestation being heaviest at the west end.

Toxaphene and chlordane were the only materials used in 1950. The sprays contained 5 pounds of a 40 per cent wettable powder to 100 gallons and were applied at the following rates: 4 and 6 pounds of actual toxaphene per acre and 8 pounds of actual chlordane per acre. The 3 plots contained 5300, 3450 and 2700 square feet, respectively.

The single application was made on July 20. In counts made on August 10 no larvae were found in any of the plots. Final counts on September 28 showed an

average of 1.3, 0.6 and 0.4 larvae per square foot, respectively, for the 3 plots.

1951 TESTS.—In 1951 only aldrin was used. The infestation in the bent grasses receiving greens management was spotty, pre-treatment counts varying from 1 to 10 larvae per square foot with an average of 4.3. The bents receiving fairway management had an average of 9.3 larvae per square foot and the infestation appeared to be uniform. One pound of 25 per cent aldrin wettable powder was used to 100 gallons and the following amounts of actual aldrin per acre were applied on July 12: 1.2, 0.6 and 0.5 pounds to the bents receiving greens management, and 0.5 pound to the bents receiving fairway management. The four plots contained 2250, 4725, 4500 and 2430 square feet, respectively.

Counts were made on July 26, August 9 and August 28. On the first date, only one larva was found in a total of 22 counts in all plots. On the second date, six counts in each of the plots receiving greens management showed an average of 0.2 larvae per square foot in the plot which received 1.2 pounds per acre, and 3.0 and 1.7 larvae per square foot in the other two plots. In the plot receiving fairway management, eight counts showed an average of 0.5 larvae per square foot.

By August 28 there was little difference between any of the plots receiving greens management and all had less than one larva per square foot. No larvae were found in the plot receiving fairway management on August 28.

TESTS WITH HAND EQUIPMENT.—Since many requests for information on the control of sod webworms are received each year from home owners, several types of hand equipment were tested in 1949. The grasses used in the tests were Merion and Kentucky bluegrass receiving fairway management and various bent grasses receiving greens management. The size of the plots was 145 square feet in the bluegrasses and 150 square feet in the bent grasses. Each treatment was repeated 2 to 4 times.

Insecticides used were: DDT, 50 per cent wettable powder; toxaphene, 40 per cent wettable powder; chlordane 40 per cent wettable powder and 25 per cent emulsifiable concentrate. The wettable powders were used at 1 level tablespoon per gallon of water and the chlordane emulsifiable concentrate at 2 tablespoons per gallon.

All of the above formulations were applied with a compressed air hand sprayer, and the DDT and chlordane wettable powders with a sprinkling can. The hand sprayer was fitted with a nozzle which threw a flat fan-shaped spray and 1 gallon was applied to a plot. With the sprinkling can, 3 gallons were required per plot. The chlordane emulsifiable concentrate was also applied with a siphon-type hose sprayer. Two tablespoons of the concentrate in a pint of water was sprayed on each plot.

Pre-treatment counts averaged 5.3 larvae per square foot in the bluegrass plots and 23.7 in the bent grass plots. The latter were treated on July 5 and 6 and the former on July 12 and 13. A second application was made to the bent grass plots on September 6.

In general, good control was obtained with all treatments. Counts were made on July 19 and out of 18 plots, 15 had no larvae or less than one per square foot. One plot sprayed with the chlordane emulsion had one larva per square foot, and one plot treated with the hose sprayer had 2.3 larvae per square foot. In one plot sprayed with the chlordane wettable powder nine larvae per square foot were found. This plot received another application on July 19, and on July 21 only two larvae were found in four counts.

DISCUSSION.—Effective control of sod webworms was obtained with DDT, chlordane, toxaphene, aldrin and dieldrin. All of the materials were applied as sprays, and except for dieldrin, were used at varying amounts per acre. Table 1 shows the amounts of active ingredient per 100 gallons of spray, the maximum and minimum amounts per acre, and the maximum and minimum number of gallons per acre applied with power equipment.

Effective control was obtained in all cases. However, in 1951 aldrin at 0.6 and 0.5 pound per acre showed little residual effect. Three weeks after treatment, the bents receiving greens management had an average of 3.0 and 1.7 larvae par square foot in the areas which received these amounts compared to an average of 0.2 in the area which received 1.2 pounds per acre. All of the larvae were small which indicated that the infestation had de-

veloped after the insecticide application.

From the standpoint of effectiveness, thorough coverage, and labor costs for treating large areas of turf, the most practical method appears to be the application of 300 to 400 gallons of spray per acre, adjusting the amount of active ingredient in the spray so as to apply 4 to 5 pounds of actual DDT, chlordane or toxaphene per acre or 1.5 to 2.5 pounds of actual aldrin per acre. This would allow some variation in the number of gallons applied per acre without the application of excessive amounts or less than the minimum required for effective control. While dieldrin is a promising material it is not recommended on the basis of a single season's tests.

Table 1.—Materials used and rates of application, sod webworm tests, 1947–1951.

Insecticide	Active per 100 Gallons	Ingredient lbs. per Acre	Gallons per Acre
DDT	0.5 (lbs.)	4.5–11.1	900–2420
DDT	1.0	2.6	260
Chlordane	0.5	4.5–11.1	900–2420
Toxaphene	0.5	4.5–11.1	900–2420
Toxaphene	1.0	4.0– 6.0	400– 600
Aldrin	0.25	0.5– 2.5	200–1000
Dieldrin	0.15	1.5	1000

The tests in 1947 and 1948 indicated that DDT, chlordane and toxaphene might have considerable residual effect and that only 1 application might be required during a season. Later tests, however, showed that under certain conditions a second application was necessary 6 to 8 weeks later. Bohart (1947) observed that during oviposition the moths concentrate where the grass is the most lush. This would explain why the bent grasses receiving greens management were generally more heavily infested in early summer than the same grasses receiving fairway management, and why reinfestation occurred to a much greater extent in the former. The plots used in the 1948 tests were not maintained well during the summer and the apparent long residual effect of the insecticides might be partially accounted for by the unattractiveness of the grass to the moths.

In the writers' experience, severe injury by sod webworms has been observed only in bent grass and new bluegrass lawns. These observations agree with those of Bohart (1947).

In 1949 the bluegrasses, bents and fescues receiving fairway management had from four to seven larvae per square foot in pre-treatment counts but showed no noticeable signs of injury. Some of these plots were adjacent to the bents receiving greens management in which the infestation was cassing serious damage. After treatment, serious reinfestation occurred in many plots of the latter but no injury was apparent in any of the plots receiving fairway management during the season.

In 1950 none of the plots receiving fairway management showed any signs of sod webworm injury while those receiving greens management had to be sprayed in July to avoid serious damage. While the bents receiving fairway management in 1951 were sprayed in July, it seems likely that serious injury would not have occurred if the spray had been omitted. No larvae were found in Kentucky bluegrass adjacent to the bents when the 1951 pretreatment counts were made.

Thus it appears that the number of insecticide applications required during a season may depend on several factors such as the type of grass, cultural practices or management, and the prevalence of moths in the area.

No injurious effects were observed from any of the materials used on any of the grasses. While the maximum amounts of DDT, chlordane and toxaphene were not used on all of the grasses included in the tests, they were applied extensively to bluegrass, and to several bents and fescues. Schread (1949) has reported that chlordane at 70 and 100 pounds per acre caused superficial injury to clover, and at 125 and 150 pounds white clover was seriously burned. At the latter levels bluegrass, fescue, and redtop were not injured but velvet and colonial bents were badly burned. However, both the clover and the bents had recovered 15 days after treatment.

While it appears that most grasses are relatively tolerant to the chlorinated hydrocarbons, and that the suggested dosages can be safely applied to all of the common lawn grasses, these materials may persist in the soil for a number of years (Cullinan 1949; Foster 1951) and the application of excessive amounts should be avoided. In the case of bent grasses which may require treatments

year after year, toxaphene should receive special consideration since it apparently is unstable in soil (Foster 1951).

SUMMARY.—Sod webworms, or lawn moths, are the most common insect pests of lawns in Southern California. Bent grass and new blugrass lawns are most likely to be injured. Effective control was obtained with DDT, chlordane and toxaphene at 4 to 5 pounds per acre and aldrin at 1.2 and 2.5 pounds per acre. Dieldrin at 1.5 pounds per acre was effective the single season it was tested.

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Toxicity of New Insecticides to Cabbage Aphids

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The infestation of the cabbage aphid, *Brevicoryne brassicae* (L.), was the principal reason that some growers in the Lower Rio Grande Valley of Texas were unable to market cabbage during the winter of 1950–51. The aphid population had increased during a period following an injurious freeze in which the farmers had ceased control measures while waiting to determine whether the cabbage would recover from the frost injury. When it became apparent that the cabbage had recovered from the freeze injury the aphid population was so great that airplane dusting or spraying with benzene hexachloride or tetraethyl pyrophosphate failed to give commercial control. Preliminary experiments were conducted to evaluate recently developed insecticides.

Good control of the cabbage aphid was obtained in the field by Bronson *et al.* (1949) with hexaethyl tetraphosphate used at the rate of one part hexaethyl tetraphosphate to 800 parts of water. Wene (1950) failed to obtain control of aphids with an airplane application of tetraethyl pyrophosphate used at the rate

FIG. 1.—Head on left sprayed with 0.13 lbs. parathion per 100 gallons water; center head from untreated plot; head on right sprayed with TM-2 at 0.19 lbs. per 100 gallons water.

Table 1.—Effectiveness of insecticides applied as high volume sprays in controlling cabbage aphids.

INSECTICIDE PER 100 GALLONS WATER	APHIDS PER SQ. IN. AFTER 2 Days		APHIDS PER SQ. IN. AFTER 4 Days	
	No.	Red.	No.	Red.
1.6 lbs. TM-3	23.3	66%	39.6	54%
0.8 lbs. TM-3	39.2	42	52.5	40
0.5 lbs. TM-4	35.5	47	56.6	35
1 qt. 20% TEPP	3.8	94	26.1	70
0.38 lbs. TM-1	0.9	99	2.7	97
0.25 lbs. Parathion	2.5	96	3.5	96
0.25 lbs. TM-2	15.2	77	33.8	61
0.38 lbs. TM-2	0.8	99	1.3	99
Untreated	67.3	—	86.9	—

Table 2.—Effectiveness of insecticides applied as high volume sprays in controlling cabbage aphids.

	Aphids Per Square Inch After							
	1 Day		8 Days		14 Days		21 Days	
	No.	Reduction	No.	Reduction	No.	Reduction	No.	Reduction
0.25 lbs. γBHC	2.8	93%	8.5	85%	26.1	59%	55.7	34%
0.13 lbs. γBHC	3.1	92	15.9	72	46.9	27	77.7	8
0.25 lbs. Parathion	0.3	99	9.4	84	23.9	63	62.0	26
0.13 lbs. Parathion	2.8	93	12.7	78	30.5	52	78.0	7
0.5 lbs. Octa methyl pyrophosphoramide	3.2	91	9.4	84	21.2	69	58.0	31
0.38 lbs. TM-2	0.2	99	0.7	99	15.0	77	27.8	67
0.19 lbs. TM-2	0.7	98	3.8	93	16.6	74	62.0	26
Untreated	37.6	—	57.7	—	64.0	—	84.0	—

of 1 pint of 20 per cent tetraethyl pyrophosphate in 5 gallons of water per acre. Hervey (1946) obtained good control of cabbage aphids with a 3 per cent gamma benzene hexachloride dust applied at approximately 17-day intervals. Ripper *et al.* (1950) obtained control of cabbage aphids for 7 weeks after a single application of octamethyl pyro-phosphoramide used at the rate of 7 pounds per 100 gallons of water per acre.

Two experiments were conducted in cabbage fields which had been abandoned because of severe aphid infestations. The cabbage in both fields had heads about 3 inches in diameter at the time of treatment applications. Each plot consisted of a single row 30 feet in length. Each treatment was replicated 3 times. The treatment sprays were applied with a 3 gallon garden sprayer at approximately 120 gallons per acre. The efficiency of the various materials was determined by pulling a single leaf from 5 plants at random in each plot. The aphids were counted in a square inch area, usually in the middle portion of the upper surface of the leaves. Two or more records were made at certain intervals after the treatment application.

The data in table 1 show that 2 days after treatment TM-1,[1] parathion, TM-5[5] and tetraethyl pyrophosphate were more effective than TM-3,[3] TM-4[4] and TM-2[2]. An examination made 4 days after treatment showed that the aphid population had increased greatly on the tetraethyl pyrophosphate sprayed plots. The control was still about the same on the TM-1, parathion and TM-5 plots as that shown 2 days after the treatment applications.

In the second experiment the effects of the insecticidal treatments were observed for a period of 3 weeks. Gamma benzene hexachloride at the rate of 0.25 pound per hundred gallons of water was still giving effective aphid control for 2 weeks while the data in table 2 show that the 0.13 pound dosage gave good control for a period of only 8 days. Parathion showed good residual effectiveness for 14 days when used at dosage rates of 0.25 and 0.13 pound per 100 gallons of water. The 0.13 pound rate was as effective as the higher concentration. The data also show that parathion was ineffective in controlling aphids 3 weeks after treatment application. Octamethyl pyro-phosphoramide, used at 0.5 pound per 100 gallons of water, showed good aphid control 2 weeks after treatment application but rapidly lost its effectiveness during the following week. TM-2, used at the rate of 0.38 pound per 100 gallons of water showed effective aphid control for a period of 3 weeks, whereas the 0.19 pound concentration gave effective aphid control for only 2 weeks. Three weeks after the treatment application a single cabbage head was selected at random from a plot sprayed with 0.13 pound parathion and from a plot sprayed with 0.19 pound TM-5 and compared with a head from the untreated

[1] TM-1, test material #1, 6.2 per cent 0,0-diethyl 0-p-nitrophenyl thiophosphate plus 24.5 per cent 0, 0-dimethyl 0-p-nitrophenyl thiophosphate plus 2.7 per cent related organic phosphates plus 66.6 per cent inert and called "Metacide" by the manufacturer.

[2] TM-2, test material #2, 30.6 per cent diethoxy thiophosphoric acid esther of 7-hydroxy-W-methyl coumarin plus 69.4 per cent inert ingredients and called "Systox" by the manufacturer.

[3] TM-3, test material #3, a new material released by Geigy Company, Inc., as G-22828.

[4] TM-4, test material #4, 8.33 per cent 2-nitrol-1, 1-bis (p-chlorophenyl) propane plus 16.67 per cent 2-nitrol-1, (p-chlorophenyl) butane plus 75 per cent inactive ingredients and called "Dilan" by the manufacturer.

[5] TM-5, test material #5, 32.1 per cent Trialkyl thiophosphate plus 67.9 per cent emulsifier 8139 and called "Potasan" by the manufacturer.

plot. Figure 1 shows that cabbage heads treated with parathion and TM-5 were much larger than untreated heads.

These tests were preliminary in nature but indicate that much more work is needed on octamethyl phosphoramide and TM-5 before they can be recommended for the control of cabbage aphids because of the residual effectiveness shown by systemic insecticides, especially TM-5.

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SCIENTIFIC NOTES

Toxicity of Aldrin to Chickens[1]

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Experiments were conducted in 1950 on 3- and 6-week old chicks to determine the acute and chronic toxic effects produced by aldrin.

Lehman (1949) reported that the acute oral dose of aldrin lies between 30 and 80 mg./kg. He also stated that aldrin is readily absorbed through the skin. Kitselman *et al.* (1949) reported that the LD-50 of aldrin for white rats was between 40 and 60 mg./kg.

Procedure.—New Hampshire chicks, 3 and 6 weeks old, were given acute oral doses of aldrin ranging from 5 to 35 mg./kg. of body weight. The toxicant was administered in small gelatin capsules to six chicks of each age group at each dosage level. In the test on chronic toxicity, 14 chicks of each age group were fed mash containing 25, 50, 100, and 200 p.p.m. of aldrin.

Results.—Symptoms of poisoning by aldrin were similar for acute and chronic doses except that they appeared earlier in the case of acute doses. Symptoms of toxicity, typical of all birds affected, were as follows! extreme nervousness, loud chirping, running in circles, flailing of wings, pecking at floor of pen, and spasms. A typical spasm was characterized by taut muscles, tremors, closed eyes, and head drawn over the back. These symptoms appeared within 30 minutes following application of the higher acute doses. Post-mortem examinations showed the intestines to be practically empty, containing only a small amount of greenish material. The gall bladders were slightly enlarged. In most cases there was a mass of food material collected in the mouth and pharynx.

Table 1.—Acuity toxicity of aldrin to chickens.

Dose in Mg/Kg of Body Weight	Per Cent Mortality	
	3-Week Old Chicks	6-Week Old Chicks
0	0	0
5	—	0
7.5	0	—
9.0	0	—
10.0	31.0	0
11.0	20.0	—
12.5	20.0	50.0
15.0	83.0	81.0
17.5	—	100.0
20.0	83.0	94.0
22.5	—	100.0
25.0	100.0	94.0
30.0	100.0	100.0
35.0	100.0	100.0

Results of the acute toxicity test are presented in table 1. When these data are converted to dosage-mortality curves, the LD-50 lies between 10 and 15 mg./kg. for both 3- and 6-week old chickens.

All of the chicks died in the chronic toxicity test, and no pathological effects were determined. The mean longevity was inversely proportional to the amount of aldrin in the diet; therefore, it appears that the upper limit of tolerance of aldrin in the diet is below 25 p.p.m.

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[1] The data herein are taken from a thesis presented by Helen Richards to the graduate faculty of Alabama Polytechnic Institute in partial fulfillment of requirements for the M.S. degree.

Repellency Test for Horse Flies and Horn Flies in New York State

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Horse flies are seldom as much of a problem on horses and cattle in New York State as they are in the more southerly regions; however, during some years in parts of the state these pests are abundant enough to cause considerable annoyance to livestock.

Tashiro & Schwardt (1949) found that a single female of the more common species, *Tabanus quinquevittatus* Weidman, could take 0.0359 cc. of blood at a feeding and *Tabanus sulcifrons* Macquart could take 0.074 cc. per feeding. Besides the blood taken by the horseflies feeding on the animal, there is also a considerable amount lost from the wound after the horse fly has left. The authors found *Tabanus quinquevittatus* Weidman, the common "green head," to be the most abundant species during the summers of 1950 and 1951 in central New York.

The horn fly, *Siphona irritans* L., is probably the most numerous dipterous pest found on cattle in the pasture during summer. Hornflies are more easily controlled than horseflies, due to their habit of remaining on the host almost continually.

Materials and Methods.—The following compounds were used as repellents in this experiment: 1) emulsifiable pyrenone, 2) butoxy polypropylene glycol,[1] 3) butoxy polypropylene glycol plus 20 per cent pyrethrum oleoresin,[1] 4) combination of bentonite sulfur 0.62 per cent and lindane 0.046 per cent, and 5) 0.5 per cent allethrin dust. The dilutions are shown in tables 1 and 2.

The sprays were applied with a small portable sprayer at the approximate rate of 1 quart per animal and at 200 pounds pressure. The dust was applied with a small, plunger type, hand duster with a shovel type nozzle. Matthysse (1946) found this type of duster to be the most efficient in confining the dust on the animal, when dusting was used as a means of cattle louse control. The dust was applied at the rate of 2.3 to 2.5 ounces per animal.

The materials were applied immediately after

Table 1.—Horse fly repellent tests for 1950 and 1951 with an average of two or more population counts.

Material	Days after Treatment 1	3	5	Total Flies	Per Cent Reduction
	No. of Flies				
Oswego, N. Y., 1950					
Pyrenone 1–5	1	4	1	6	86
Pyrenone 1–10	1	2	—	3	93
Lindane and Bentonite sulfur	6	4	4	14	67
Butoxypolypropylene glycol[1] 1–9	1	4	3	8	80
Butoxypolypropylene glycol plus 20% pyrethrum oleoresin[2] 1–5	1	6	6	13	69
Allethrin dust	10	7	6	23	45
Check	14	16	16	46	
Ithaca, N. Y., 1950					
Pyrenone 1–10	0	2	1	3	87
Pyrenone 1–15	0	1	2	3	87
Pyrenone Dust	3	6	4	13	43
Butoxy polypropylene glycol[1]	0	3	0	3	87
Lindane and Bentonite sulfur	0	4	4	8	65
Check	7	10	6	23	
Oswego, N. Y., 1951					
Pyrenone 1–5	4	6	2	12	78
Pyrenone 1–10	4	16	4	24	56
Pyrenone 1–15	3	2	2	7	87
Check	20	29	5	54	
Ithaca, N. Y., 1951					
Pyrenone 1–5	4	7	0	11	83[3]
Pyrenone 1–10	3	8	0	11	83[3]
Pyrenone 1–15	2	1	0	3	75
Check	3	9	0	12	

[1] Crag Fly Repellent I—Carbide & Carbon Chemical Corporation.
[2] Livestock spray containing Crag Fly Repellent I—Carbide & Carbon Chemical Corporation.
[3] Low count on check head due to adverse weather conditions.

Table 2.—Horn fly repellent tests for 1950 and 1951 with an average of two or more population counts.

Material	Days after Treatment 1	3	5	Total Flies	Per Cent Reduction
	No. of Flies				
Oswego, N. Y., 1950					
Pyrenone 1–5	2	11	32	45	96
Pyrenone 1–10	1	7	55	63	94
Lindane and Bentonite sulfur	8	25	100	133	87
Butoxy polypropylene glycol[1] 1–9	10	77	61	142	86
Butoxy polypropylene glycol plus 20% pyrethrum oleoresins[2] 1–5	5	45	85	135	87
Allethrin dust	25	257	205	487	53
Check	305	413	312	1030	
Ithaca, N. Y., 1950					
Pyrenone 1–10	5	20	35	60	90
Pyrenone 1–15	5	25	45	75	88
Pyrenone dust	40	145	165	320	49
Butoxy polypropylene glycol[1]	25	35	75	135	78
Lindane and Bentonite sulfur	25	55	100	180	71
Check	200	235	190	625	
Oswego, N. Y., 1951					
Pyrenone 1–5	60	28	91	179	95
Pyrenone 1–10	17	156	185	358	91
Pyrenone 1–15	12	22	171	205	97
Check	1430	1485	1015	3930	
Ithaca, N. Y., 1951					
Pyrenone 1–5	0	15	—	15	99
Pyrenone 1–10	0	25	—	25	98
Pyrenone 1–15	25	100	—	125	91
Check	125	1250	—	1375	

[1] Crag Fly Repellent I—Carbide & Carbon Chemical Corporation.
[2] Livestock spray containing Crag Fly Repellent I—Carbide & Carbon Chemical Corporation.

milking in the morning while the animals were still in the stanchions. Counts were taken in the mid-afternoon on the day of application and on the third and fifth days thereafter. The figures in tables 1 and 2 represent the total number of flies counted on one side of 10 animals. The interval covered by these tests was from June 23 to August 15, with the majority of the tests being conducted in the month of July.

SUMMARY AND CONCLUSIONS.—Horse fly and horn fly repellency tests were conducted on dairy herds located in the vicinities of Oswego and Ithaca, New York. During the summer of 1950 emulsifiable pyrenone appeared to be the most effective material tested and the second summer was devoted to determining the best dilution of pyrenone for control of each of the insects. In 1951 pyrenone was tested in three different dilutions as shown in tables 1 and 2. The 1 to 10 dilution appears to the best for horse fly repellency. There is very little difference in the effectiveness of the three dilutions for horn flies.

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Control of the Cattle Mange Mite

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When mange was first reported in New York State in 1943, the scaroptic mite, *Scaroptus scabiei* var. *bovis* Robin, was the principal cause of mange, Baker (1947). This mite remained a serious pest until the winter of 1950–51 when the chorioptic mite *Chorioptes bovis*, apparently became more abundant.

Mange lesions appearing as small nodules are first found on the escutcheon and the insides of the hind legs of cattle. Unless controlled the mites will spread to all parts of the body, causing a severe irritation to the skin. A glue-like exudate is found on the surface of the skin when the mange lesions become severe. The chorioptic mite passes the summer on protected places on the animal's body, chiefly the escutcheon.

The chorioptic mange mites are spread mostly by direct contact of one animal with another. Mange is spread from herd to herd chiefly by the trading of animals. Many of the better dairymen of the state refuse to trade at all and raise all of their replacements.

This control experiment was conducted on 21 herds totaling 506 animals located in Tompkins County, N.Y. One of the 21 herds was purebred Hereford, the rest being dairy animals. All of the

Table 1.—Mange control results for 1951.

No. Animals	Date Treated	Materials and lbs. per 100 Gals.		Control After 1 Months	2 Months	3 Months	Final Months
12	1–14	70% Sulfur Paste[1]	10	No	No	No	No
28	1–15			Ex	Ex	Ex	Ex
58	1–18			Ex	Ex	No	No
29	2–5	Wettable Sulfur Lindane	10 1.5	Ex	Ex	Ex	Ex
43	2–6			Ex	Ex	Ex	Ex
19	2–6			Ex	Ex	Ex	Ex
22[2]	2–6			Ex	Ex	Ex	Ex
11	2–12	Lindane	1.5	Ex	Ex	Ex	Ex
36	2–17			Ex	Ex	Ex	Ex
12	2–17			Ex	Ex	Ex	Ex
29	2–17			No	No	No	No
14	2–19	Wettable Sulfur	10	Ex	Ex	Ex	Ex
30	2–27			Ex	Ex	Ex	Ex
33	2–27			Ex	No	No	No
20[3]	3–5			Ex	Ex	Ex	Ex
20	3–7	Bentonite Sulfur	6	Ex	Ex	—	Ex
10	3–7	Lindane	0.5	Ex	Ex	—	Ex
16	3–12			Ex	Ex	—	Ex
30	3–7	50% technical p-chlorophenyl phenyl sulfone[4]	4	Ex	No	—	No
20	3–7			Ex	No	—	No

[1] Magnetic 70 Sulfur Paste—Stauffer Chemical Company.
[2] Sarcoptic mange present.
[3] Hereford cattle.
[4] Experimental compound R 272—Stauffer Chemical Company.

common breeds were represented in these herds.

The season was late in 1950–51 which allowed the animals to remain on pasture until November, and most of them were back on pasture by May 15. Since mange does not usually occur until the cattle have been in barns for a period of 4 to 6 weeks, and disappears when the animals are turned out in the spring, the longest period of control for any material was slightly over 3 months.

MATERIALS.—Schwardt, 1949, found that benzene hexachloride used at the rate of 6 pounds of 6 per cent gamma gave good control for 1 year. Wettable sulfur at the rates of 20 pounds and 30 pounds had given good results when used in the mange control program in New York in previous years.

The six materials used in the 1950–51 mange control program were as follows: 1) 70 per cent finely ground sulfur paste;[1] 2) lindane; 3) wettable sulfur plus lindane; 4) bentonite sulfur plus lindane; 5) wettable sulfur; and 6) 50 per cent technical p-chlorophenyl phenyl sulfone.[2] The concentrations are shown in table 1.

PROCEDURE.—Two applications of each material were applied at intervals of 7 to 11 days.

The materials were applied as a spray suspension, with a 150 gallon hydraulic sprayer, having a pump capacity of 7.5 gallons per minute. The materials were sprayed directly on the animals at 400 pounds pressure to assure penetration of the liquid through the hair and scab. The rate of application varied from 1.5 to 2 gallons per animal depending on the size and condition of the individual. Spray was usually applied until run-off occurred.

A pistol-grip swivel type cut-off was used with a 5-foot extension of quarter inch galvanized pipe. Two orchard type nozzles were attached to the pipe in line, one on the end and one 8 inches from it. The nozzles were equipped with 6-hole whirl plates and No. 5 discs in order to obtain sufficient volume and drive.

The animals, except the one beef herd, were sprayed while in the stanchions. To avoid possible disease transmission and to prevent unnecessary excitement in the herd, the operator did not spray from the front of the animals. With a 5-foot extension on the gun the heads could be reached from the side positions. The spray rod was held approximately 12 inches from the animal to allow maximum coverage and penetration.

Although the outside temperatures frequently were near 15° F., the inside temperature of tight barns was approximately 40° F. Most of the New York barns were in good condition and during the treatment of the 506 animals there was no report of any ill effects due to spraying in cold weather.

Checks were made at the time of the second application and at monthly intervals thereafter. The final check was made just before the animals were turned out in the spring. The most heavily infested animals in each herd were selected and recorded on the data sheet. Scrapings were taken from the edge of the mange lesions with the lid of a small salve tin, scraping deep enough to draw blood. Deep scrap-

[1] Magnetic "70" Sulfur Paste—Stauffer Chemical Company.
[2] Experimental Compound R 272—Stauffer Chemical Company.

ings are necessary since the sarcoptic mite lives below the surface of the skin. All of the animals in the herds were examined at each check in order to determine if the mange had spread.

The scrapings were examined and the degree of control was established in the following manner:

1. Examined under the microscope for live mites and if mites were found, this was considered *no control.*
2. If no mites were found, scrapings were treated according to the method developed by Dr. D. W. Baker and reported by Schwardt (1949). The presence of mites indicated *far control*
3. The absence of mites in both tests denoted *excellent control.*

RESULTS OR 1950–51—The results of these experiments are presented in table I. The combination of the lindane and wettable sulfur gave the most effective control. Lindane or wettable sulfur alone appeared less effective than the combination. Lindane would be preferred over wettable sulfur since it controls all species of cattle lice present as well as mange mites.

SUMMARY—The chorioptic mange mite appeared to be the most abundant species of mites on dairy animals in New York State in 1950–51.

Six materials were used and a total of 21 herds totaling 506 animals were sprayed twice. The combination of lindane and wettable sulfur was found to be the most effective spray material. The spray should be applied at 400 pounds pressure to assure penetration through the hair and scab.

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Insect Pollination of Ladino Clover in South Carolina[1]

DAVID DUNAVAN[2]

The extensive use of Ladino Clover in the pasture program in the Southern States has created a heavy demand for seed. In 1949 there were in South Carolina 16,057 acres of Ladino Clover grown for seed. The acreage for 1950 is not known at present, but 554 acres were grown for certified seed production.

Successful seed production, of course, depends largely on the amount of pollination of the blossoms. During the month of June (1950) an investigation of this matter was started at Clemson, South Carolina. The objective was to answer two questions:

(1) What insects are responsible for pollination of Ladino Clover?

(2) To what extent are honey bees responsible for pollination of the crop?

An area in an established pasture consisting of a good stand of Ladino Clover and Kentucky 31 Fescue was selected. Plots were located in this area and the following treatments provided for:

A. Pollinating insects excluded by screen
B. Honey bees only
C. Open pollination

The last mentioned plots in reality had no treatment at all and served as controls or checks. Screen cages about 4 by 4 feet square and 3 feet high constructed of 16-mesh bronze screen were used. Each treatment was replicated once.

Table 1.—Pollination results, Ladino clover, Clemson, South Carolina 1950.

	NUMBER OF SEEDS PER 50-HEAD SAMPLE FROM PLOTS REPLICATED ONCE		
	No insects	Open pollinated	Honey bees only
Plots 1, 2, & 3	68	3712	3798
Replicate plots	204	3552	5189
Totals of both plots	272	7264	8987
Average number of seeds per head	2.72	72.64	89.87

On June 28 when the investigation was started the clover in the pasture was in full bloom. Immediately before cages were set in place all heads were picked from clover plants on the plots. These heads were discarded.

Each cage in which only honey bees were allowed had a hive of bees placed against one side. The hive had one entrance opening into the cage and another arranged for free flight outside. (Fig. 1.) For the first few days small numbers of honey bees failed to find their way back into the hive from the interior of the cage and had to be shaken out for a fresh start. Very soon, however, the bees were observed to work freely on blossoms inside the cage and later to reenter the hive.

The cages set up to exclude pollinating insects were checked frequently. At times a few leafhoppers and other small insects were found and removed. No insects of any consequence as pollinizers apparently entered as the results will show.

In early August the investigation was terminated. All heads from each plot were harvested. A sample consisting of 50 representative heads was taken from each plot in order to make seed counts. The results were somewhat surprising. (Table 1.)

It will be noted that the samples from the plots where honey bees only were allowed yielded more seed in both cases than those from plots open to all pollinizers. The above figures are based on 50-head samples as noted previously.

In contrast with this, when total numbers of seeds from each of the plots were compared it was found that the open pollinated plots produced more seed than the plots pollinized by honey bees only.[3] Possibly the exclusion of sunlight by the screen and the framework of the cages inhibited the number of blossom heads produced by these plants.

The major portion of the pollination was evidently being done by honey bees. Comparative counts of honey bees with other pollinizers showed a ratio of approximately 10 honey bees to each hymenopterous pollinizer other than the honey bees. The other Hymenoptera involved proved to be predominately small bumblebee workers. There were a few miscel-

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[3] Because of the physical impossibility of manually counting all seeds produced on the plots these figures represent estimates based on actual counts of small weighed samples of representative seed.

laneous small solitary bees of the andrenid type and an even smaller number of Megachilidae.

In order to get more specific information regarding seed production of Ladino clover a change in approach to the problem was made during the 1951 season.

The following data were obtained from essentially the same area of pasture as was used in the 1950 investigation. Bees from an apiary less than one-half mile away worked the clover in this pasture actively for both nectar and pollen through most of the summer. Counts made at intervals indicated that the average honey bee population of this area was about two honey bees per square yard.

On July 10 representative ripe clover heads were picked in order to make seed counts.

A brief description of the make-up of the ripe Ladino clover head might be of interest here. As is true with all clovers of the genus *Trifolium*, the head is made up of many florets, each of which somewhat resembles a pea blossom in miniature. Fig. 1A.

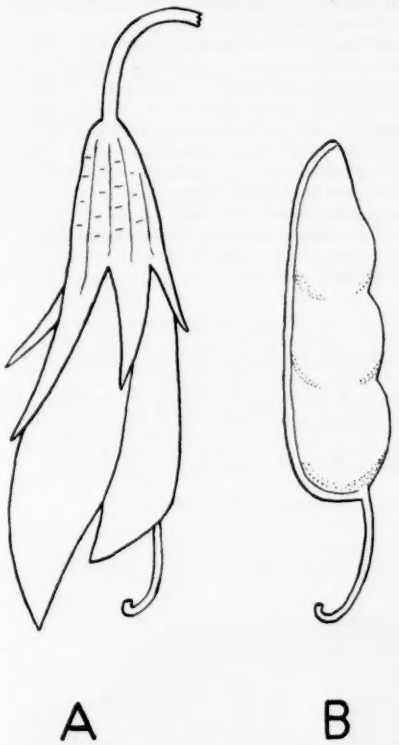

FIG. 1. A. Ripe Ladino clover floret. B. Seed pod removed from floret.

When the head ripens, each of these little florets turns brown and changes from its original erect position to hang downward. Inside of this ripe floret will be found a small pod with a variable number of seeds enclosed. See Figure 2B. From the end of this pod projects the remains of the stigma and style.

Table 2 represents a count made with the aid of a microscope of all the seeds in 25 heads. It will be noted that the number of seeds produced by each floret varied from none to as many as seven. The highest number of florets found in any one head was 135, while the average number was 84.4. It will be seen from a study of table 2, column 4 that the greatest number of florets produced three seeds each.

Table 2.—Seed counts of 25 Ladino clover heads showing distribution of seeds per floret.

Head No.	Seeds per Floret[2]						Total Florets	Total Seeds per Head
	None	1	2	3	4	5		
1	34	10	23	30	8	1	106	183
2	5	16	63	41	10	0	135	303
3	12	21	40	26	10	3	112	234
4	11	36	28	23	6	0	104	185
5	3	1	16	24	15	2	61	175
6	2	3	5	22	39	13	87	318
7	11	25	26	11	11	6	93	202
8	3	2	21	37	17	2	83	239
9	2	7	14	24	19	5	71	208
10	11	55	44	15	3	0	128	200
11	7	6	12	37	25	0	88	247
12	14	10	28	32	10	0	94	202
13	5	5	13	17	23	1	64	179
14	1	0	2	9	26	14	55	223
15	3	7	13	20	20	12	79	257
16	13	14	28	34	14	1	104	243
17	13	11	26	25	7	2	84	176
18	2	1	5	25	40	0	73	246
19	21	16	12	8	2	0	59	72
20	15	7	13	32	14	5	86	210
21	5	6	14	34	20	15	94	291
22	15	13	21	28	12	7	96	222
23	1	6	27	25	9	2	70	181
24[1]	9	3	16	27	17	15	90	279
25	23	7	16	20	4	0	70	115
Totals	241	288	526	626	381	106	2186	5390
Averages							84.4	215.6

[1] Two florets showed seven seeds each: sixteen showed six seeds each. Thus, because of omission of these data from the table, certain of the above totals will seemingly be in error.
[2] Average number of seeds per floret—2.46.

The greatest number of seeds produced by one head was 318 while the smallest number was 72. The average seed production per head was 215.6.

DISCUSSION.—Comparison of the data based on the above counts with the results obtained in 1950 (Table 1) shows some striking differences. Worthy of note is the fact that the average seed production per head in 1951 is so much greater than the average for 1950. What factor or factors are responsible for this variation is a matter for conjecture.

Of course there is no assurance that the data obtained in these investigations are indicative of the maximum seed production of Ladino clover. Remarkable results in seed production of certain legume crops have been attained in certain sections of the United States by so called saturation pollination with honey bees. Similar results might also be achieved with Ladino clover if sufficient pollinizers were provided.

There is always the possibility that seed production of Ladino clover is to some extent either directly or indirectly dependent on soil condition or fertility level. The history for the past several years of the pasture area involved in the present investigation would indicate that the needs of the plants had been adequately provided for.

SUMMARY.—Ladino clover blossoms produced almost no seed when pollinating insects were excluded by screen.

Blossoms on caged plants visited only by honey bees produced more seed than open pollinated blossoms.

The greatest number of seeds produced by a single Ladino clover head was 318. The average seed production per head was 215.6.

The greatest number of florets found in a Ladino clover head was 135.

A single floret was found to yield as many as seven seeds, but the average was 2.46 seeds per floret.

Stink Bug Injury to Tomatoes in California

A. E. MICHELBACHER, W. W. MIDDLEKAUFF and O. G. BACON

Tomatoes injured by stink bug feeding have been encountered in California tomato fields for many years. The damage has occurred sporadically over a wide area but was never found in sufficient amounts to be of any real concern or to justify time to determine the cause. It was not until this past season, when several fields showed damage, that the injury was definitely associated with stink bug attack.

While conducting a survey of our tomato experimental plots at Woodland, California, on July 20, 1951, the injury was found in amounts to create some interest. The damage was definitely associated with the red-shouldered plant bug, *Thyanta custator* (Fab.). The bugs were present in more than usual numbers and it is believed that they had moved into the tomato field from surrounding clover and alfalfa seed fields, which were known to contain a fair infestation.

Our attention was next directed to a tomato field located near Clarksburg, Sacramento County, where serious damage was being inflicted. This field was examined on August 26, and in the half which was located next to an alta fescue seed field which was harvested about July 1, a very large proportion of both the green and ripe fruit was injured. In this case the insect involved was the consperse stink bug, *Euschistus conspersus* Uhler. It was present in abundance and in all stages of development. There is little question but that the fruit of tomato served as a satisfactory host for the insect. Furthermore, it appeared that the green fruit was preferred, and was the primary food on which the bugs developed. In order to check the damage it was suggested that the field be treated with a 10 per cent toxaphene dust at the rate of 30 pounds to the acre. The field was treated by airplane and the control obtained was sufficient to insure a satisfactory harvest. At the rate used the toxaphene gave effective control of the nymphs.

Feeding by stink bugs results in the destruction of the cells just beneath the skin. The injury is very characteristic and hardly extends to a depth of more than one sixteenth to one eighth of an inch. The tissue below this area appears normal in every respect. Where the feeding has been extensive on green fruit, the surface of the fruit appears mottled and relatively soft or spongy due to the destruction of the tissue just beneath the surface. If a shallow surface cut is made through the injured area the tissue beneath the skin is nearly white and somewhat cottony in appearance. The mottled condition persists in the ripe fruit, and the injured area continues to be soft and spongy. Where injury is severe the skin of the tomato is slightly depressed. The destroyed tissue remains white and cottony in appearance as it does in the green fruit. Where feeding on green fruit has not been severe there is some tendency towards recovery.

The exact point at which the feeding puncture is made is often very difficult to detect. It is not easily seen and at most appears as a tiny spot, sometimes dark in color and slightly raised.

Ripe tomatoes that have been injured by plant bugs are shown in figure 1.

Stink bug injury to tomatoes in other tomato growing areas is not unknown and it has attracted the interest of plant pathologists. Gardner and Kindrick (1931) in their investigations on tomato bacterial spot in Indiana noted that stink bugs fed on tomato fruit. Later (1923) these same workers not only produced typical injury by caging stink bugs on tomatoes, but also published a figure showing characteristic damage to green fruit. Doolittle (1943) in his publication on tomato diseases describes and figures the damage caused by stink buts and refers to it as "cloudy spot" which is very descriptive of the injury.

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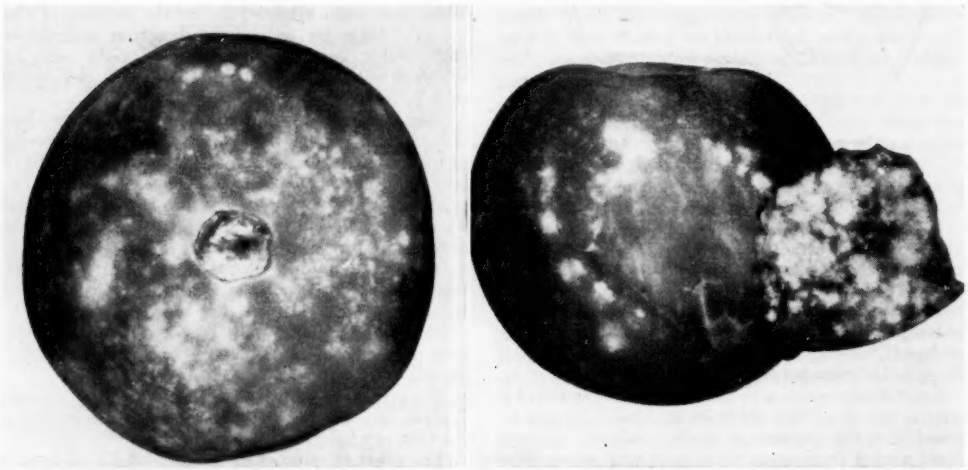

FIG. 1.—Stink bug injury to tomato. A surface cut has been made in the fruit to the right to show the whitish cottony destroyed tissue just beneath the skin.

Termite Treatment with Aqueous Solution of Chlordane

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Three years after the injection of a 1 per cent aqueous solution of chlordane in the soil around the foundation of an Urbana, Illinois, residence (Shelford 1949, 1950), the writer repeated the third set of soil tests within 0.5 and 2.0 inches from the foundation (beginning October 16, 1950). Samples were taken at the approximate depths of 3 inches and 6 inches with greater accuracy than in former years.

In the preceding two tests, 22 cc. vials were used with 4 cc. of soil. The vials were tightly corked and contained a paper label slip which sometimes kept the termites from contact with the soil. In the tests just completed, 5 cc. stender dishes with ground glass covers were used containing 3 cc. of soil. This was to prevent termite losses due to moving and rotating the vials in the process of making observations. In the change to the stender dishes free space was reduced from 18 cc. to 2 cc. in the expectation that with only ground glass seals, the humidity could be held at a higher level than with larger free space.

Four check experiments were set up: one in a 300 cc. finger-bowl dish with a loose glass cover containing 20 termites in soil scraped from the board under which the termites were collected; three others were prepared in 5 cc. stender dishes using soil similar in texture to that adjacent to the house foundation. The test soils from the foundation were collected from the centers of the west, north, and east sides of the house but not in the exact spots used in 1948 and 1949. Six to 10 worker termites were placed in each of the nine 5 cc. test dishes. The general results are shown in the table below.

In the large check, all the termites lived through the testing period. In two of the small checks, all the termites died from fungus attacks, in one at the end of 6 days, and in the other at the end of 8 days. In the third small check, the termites were in good condition when the test was discontinued at the end of 11 days. More fungus grew in the garden soil than in the treated foundation soil. Some termites that died from chlordane effects were covered with fungus in 24 to 48 hours.

Table 1.—Time to paralysis and death of worker termites in soil from 3 inches depth.[1] Notes show differences in the soil from 6 inches.

At End, Hours and Days	West	North	East
1.3 hrs.	Jerky	OK	OK[2]
2.0 hrs.	Stagger	OK	Stagger
3.2 hrs.	No Loc.	Sl. Loc.	No Loc.
8.0 hrs.	No Loc.	No Loc.	No Loc.
24.0 hrs.	Limbs	Limbs	Limbs
48.0 hrs.	1 dead[1]	Limbs	Limbs
4 days	All dead	All dead	5 dead[3]
10 days			1 alive All dead

Checks in garden soil; W. died of fungus after 8 days, N. was alive on the 11th day, E. died from fungus after 6 days.

No Loc. = Locomotion impossible; Sl. = Slight body movements; Limbs = Movement of limbs only.

[1] None dead in 6 in. soil.

[2] Jerky in 6 in.

[3] All dead in 6 in.; the one alive showed faint twitching of the tarsi for 6 more days.

A certain soil moisture content is essential to the normal life of the workers, although the exact content is undetermined. In these tests, there were evident moisture effects in the controls. In the three small checks and in six experiments, the workers were compelled to walk over the soil; termite nervousness occurred in the drier control soil after 24 hours. This condition ended when water was added, but when an over-adequate amount of water was added, some of the termites stuck to the soil and all died of fungus attack, as noted above.

Paralysis was delayed in the samples from the north side of the house. Less chlordane was added to the soil of the north side of the foundation than to either the east or west. The injections were made at more irregular distances from each other and greater variation is to be expected from random sample to sample (Table 1). The delayed paralysis is not interpreted to mean that the chlordane in this area had disintegrated, but rather that the samples came from a point which received a small original dosage.

The variation in time until paralysis in the north side tests brings out the fact that there is not a direct correlation between time until paralysis and time until death. Paralysis does, however, always end in death. There is no doubt that the toxicity of the chlordane is effective after 3 years and there is no evidence that it has deteriorated.

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Persistence of DDT on a Treated Surface as Shown by House Fly Knockdown and Kill[1]

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The advent of insecticides having residual contact effect presents interesting complications. Recent entomological literature has contained many reports of the persistence of DDT on treated surfaces. It is clear from these that the length of persistence varies greatly with type and composition of surface, temperature, exposure to weathering, formulation, and other factors. Conclusive evidence has been presented by Quayle 1922, Hough 1934, Knipling 1942, and others, that certain populations of different species of insects have developed resistance to insecticides that have been used against them over a period of years. Recent work, notably by Lindquist & Wilson (1948), March & Metcalf (1949), and King & Gahan (1949), shows the house fly, under the conditions with which these men were working, developed a marked increase in resistance to DDT during the short time this material has been in use. Recent failures to get the degree of house fly control that was experienced when DDT first became available has led workers in many localities to the conclusion that their fly populations are much less susceptible

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Table 1.—House fly knockdown and mortality resulting from exposures to the ceiling of a milking barn at different time intervals after treatment with a kerosene solution of DDT.

DATE EXPOSED	TIME—TREATMENT TO EXPOSURE		TEMPERATURE AT CAGING	KNOCKDOWN AND MORTALITY
	Years	Days	°F	
1947				
10/3	3	45	68	2 hrs. 30% down; 5 hrs. 100% down; 20 hrs. 100% dead.
Check	3	45	68	20 hrs. 100% alive.
1948				
9/2	4	11	79	3.5 hrs. 10% down; 5 hrs. 25% down; 19 hrs. 100% dead or down.
Check	4	11	79	19 hrs. 2% dead.
9/4	4	13	72	12 hrs. 98% dead; 2% moribund.
9/6[1]	4	15	72	12 hrs. none dead; 24 hrs. 7 dead.
9/6[2]	4	15	72	12 hrs. none dead; 24 hrs. 5 dead.
1949				
8/31	5	9	72	7 hrs. no flies down, several nervous; 26 hrs. 66% dead, remainder moribund.
Check	5	9	72	26 hrs. 7% dead.
1951				
8/3[3]	7	−19	74	16 hrs. 92% dead or moribund; 21 hrs. 4 alive; 40 hrs all dead.
Check	7	−19	74	40 hrs. 2% dead; 64 hrs. 2% dead.
8/23	7	1	76	2 hrs. none down; 5 hrs. 40% down; 16 hrs. 97% down; 24 hrs. 100% dead.
8/23[4]	7	1	76	2 hrs. none down; 5 hrs. 40% down; 16 hrs. 87.5% down; 24 hrs. 88% down; 40 hrs. 96% down.
8/23	7	1	76	2 hrs. none down; 5 hrs. 75% down; 16 hrs. 99% down; 24 hrs. 100% dead.
Check	7	1	76	16 hrs. 1% dead; 24 hrs. 3% dead; 40 hrs. 40% dead, food and water gone.
8/23[5]	7	1	76	5 hrs. 22% down; 16 hrs. 47% down; 24 hrs. 59% down; 40 hrs. 92% down.

[1] Cage placed on ceiling directly above a south window.
[2] Cage placed on ceiling directly above an east window.
[3] Two cages of 100 flies each.
[4] House flies reared in the laboratory from wild flies taken in Colorado A & M College Dairy. Two cages of 100 flies each.
[5] The false stable fly *Muscina stabulans* (Fall) reared from eggs deposited on house fly larva medium placed in this barn.

to DDT than previously. That resistance has developed in wild house fly populations has been clearly shown in laboratory tests by March & Metcalf (1949), King & Gahan (1949) and others. The problem is further complicated by the evidence presented by Hough (1934), Wilson & Gahan (1948) and others, showing that populations developing resistance to one insecticide may show an increased resistance to many other materials. The method of selecting in some cases, apparently results in the development of a strong stock rather than one having a specific resistance. Sternburg & Kearns (1950), and Perry & Hoskins (1950), have presented evidence to indicate that resistance to DDT by certain strains of house flies is due to development of a mechanism by which DDT is detoxified. March & Metcalf (1949), Weiner & Crow (1951), and other workers have shown that this mechanism operates in varying degrees against other compounds related to DDT.

A deposit, sublethal to an entire population or insufficient for a satisfactory economic control, may be very important from the standpoint of selecting the resistant individuals. It is conceivable that this may operate with many species frequenting the environs and resting upon the treated surfaces.

In this connection some notes taken over a period of years, on a DDT treated milking barn, near Fort Collins, are of interest. This barn was treated August 22, 1944, just a few weeks after it was built, and has had no insecticides with residual properties used in it since. It is 25.5 feet wide, east and west, by 31.5 feet long, north and south, with a 6 foot 5 inch ceiling and a cement floor. There is a 9.5 by 10 foot milk room in the northwest corner from which one enters the milking room by way of a narrow passage with two swinging doors kept closed by springs. The milking room proper, which is used only during the milking periods, contains 14 stanchions. The cows enter through a 45 inch door on the east. There are eight, 22 by 29 inch windows, two on the west, four on the south and two on the east. These are 3 feet, 10 inches from the floor. Small chains permit them to be opened inwardly, 8 inches from the top. The windows are kept closed much of the time while the upper half of the 45 inch door is open a considerable portion of the time. The barn is finished on the inside with a cane fiber board painted at the factory.

The barn, including stanchions, was sprayed by means of paint gun applicators, August 22, 1944, using a solution of DDT in deodorized kerosene, at the approximate rate of 1 gallon to 1000 square feet. The DDT solution had been supplied from Washington, D. C. by the U. S. Bureau of Entomology and Plant Quarantine. The containers

were labeled as carrying 5 per cent DDT and 95 per cent kerosene. An excellent kill of house flies and horn flies was secured during the late summer and fall. No records were taken of other species. The kill during 1945 appeared to be equal to that of 1944. Flies were not a serious problem about the premises. A visit to the barn after the evening milking September 22, 1945, 13 months after treatment, showed the flies that remained in the barn after milking were beginning to fall from effects of the DDT. Papers were placed on the floor and the insects from these taken the next morning for examination. A few were also collected from the sills of the south windows. These sills had been cleaned 2 days earlier. No live insects were found when the barn was opened. The collected material was determined by Dr. M. T. James as follows:

Musca domestica L.	143
Muscina stabulans (Fall)	16
Fannia canicularia (L.)	101
Stomoxys calcitrans (L.)	15
Siphona irritans (L.)	174
Phaenicia sericata (mg.) Greenbottle fly	22
Omphrale fenestrala (L.) Window fly	3
Aëdes dorsalis (Mg.)	1
Simulium bivittatum Ma.	14
Simulium sp.	16
Anacampta latiuscula (Lw.)	1
Pegomya ssp.	2
Lonchaea sp.	1
Paregle cinerella (Fall.)	6
Hydrotaea armipes (Fall.)	12
Helcomyzidae	1
Leptocera spp. (Borboridae)	830
Heleidae (*Culicoides* etc.)	35
Miscellaneous small Diptera	40
Miscellaneous (not Diptera)	20
	1453

Observations during 1946 showed that a very large percentage of all Diptera remaining in the barn after the evening milking were dead by morning. A very noticeable knockdown continued during 1947, the third season after treatment. On October 3, approximately 37.5 months after the barn had been sprayed, 100 laboratory reared house flies 4 days old, were caged on the ceiling near the center of the barn and 100 from the same culture placed in a similar cage with wrapping paper between them and the treated surface. These were caged at 11:40 A.M. None of the flies in the treated cage showed effects of DDT in 20 minutes, however, at the end of 2 hours 30 per cent were down. After 5 hours all were down. At the end of 20 hours all were dead while none were dead in the protected cage. Both groups were given a mixture of half milk and half water for food. The temperature at the time of caging was 68° F. and the minimum temperature during the night was 44° F.

Following this experience the owner of the barn and the dairy inspection officials agreed to permit the use of the barn to continue without additional applications of insecticides of the residual type.

Caged house flies have been placed in the barn each season with the exception of 1950. The knockdown and mortality effects on the flies caged on treated surfaces are given in table 1. In all cases, unless otherwise stated, 100 3 to 5 day old laboratory reared house flies of the NAIDM strain were used in each cage, with a mixture of half milk and half water available in cellucotton for food. The flies were anaesthetized with CO_2 for handling.

It will be noted from table 1 that a definite lethal effect to house flies has persisted for a period of 7 years. This was sufficiently effective for 4 seasons to give a practical house fly control even though sanitary conditions about the barn favored fly breeding. There was good evidence that uncaged wild house flies were killed after resting over night on the walls during the seventh year after treatment. The two tests made September 6, 1948 indicate that the DDT was less persistent where exposed to the light and air above south and east windows. An attempt was made in August 1951 to secure a culture of wild house flies from the Peterson barn to test for resistance to DDT. Jars of larval medium exposed for egg deposition produced only the false stable flies, *Muscina stabulans* (Fall). These when caged on the treated surface August 23, 1951, proved to be more resistant than house flies. House flies reared from wild flies from the Colorado A & M College dairy barn, where DDT had been used freely from 1944 to 1947, showed resistance. Two cages containing 100 flies each had 12 per cent alive at the end of 24 hours while none were alive in the cage containing the NAIDM strain, and 4 per cent were alive and active after the extreme exposure of 40 hours.

It is likely that much of the persistence of toxicity in this barn is due to the "blooming out" of DDT that had been carried into the paint and the pressed cane fiber wall covering. Tests made by Bruce 1949, showed wood panels and brick and galvanized surfaces when treated with DDT and stored inside to exhibit greater toxicity to house flies after 152 days than did similarly treated *Cellutex*, resembling *Celotex*. Such wall surfaces are in common use and the implications from the standpoint of food contamination and the development of resistant strains of insects are many.

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Toxicity of Chlordane to Chickens

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Experiments were conducted in 1950 to determine the acute and chronic toxicity of chlordane to chickens.

Ingle (1947) reported that the LD-50 of chlordane to white rats appeared to be between 225 and 250 mg/kg of body weight. Rosenberg & Tanaka (1950) found that chlordane, when fed at concentrations ranging from 0.10 to 0.25 per cent of the total ration, was poisonous to one-week old chicks. Roesnberg & Adler (1950) obtained similar results in an experiment using chlordane and DDT.

PROCEDURE.—Three- and 6-week old New Hampshire chickens grown on a commercial starting mash were used in tests on the acute and chronic toxicity of chlordane. Acute toxicity was determined by giving a single dose by oral application in small gelatinous capsules. The dosage range was from 175 to 250 mg/kg of body weight. Six to 10 chickens were used at each dosage level in each age group. In the test on chronic toxicity, 14 chickens of each age group were placed on rations containing 250, 500, and 1000 p.p.m. of chlordane for a 12-week period.

RESULTS.—The results of the test on acute toxicity are presented in table 1. When these data were converted to dosage mortality curves, the LD-50 for both age groups was between 220 and 230 mg/kg of body weight. In the test on chronic toxicity, all chickens in both age groups receiving concentrations of 500 and 1000 p.p.m. of chlordane in the diet died before the end of the 12-week feeding period. The longevity was inversely proportional to the amount of chlordane in the diet. One chicken in the younger and four in the older group receiving 250 p.p.m. survived the 12-week feeding period. The mean weight of the younger group receiving 250 p.p.m. of chlordane was 1517 gm as compared to 2010 gm for chickens receiving no chlordane. In the older chickens the mean weight at the end of the feeding period was 2330 gm for the chickens that received no chlordane; it was 1594 gm for those receiving 250 p.p.m. of chlordane in the diet.

Table 1.—Acute toxicity of chlordane to chickens.

Dose in mg/kg of Body Weight	Per Cent Mortality	
	3-Week Old Chicks	6-Week Old Chicks
175.0	33.0	0.0
187.5	40.0	0.0
200.0	26.6	20.0
212.5	33.0	20.0
225.0	53.3	66.6
231.0	—	80.0
237.5	—	60.0
244.0	—	90.0
250.0	73.3	86.6

Symptoms of chlordane poisoning, characteristic of all chickens affected, were loud chirping associated with general nervousness and spasms. After several spasms, an affected bird could not regain a standing position but would rest on its keel and shake its head as if trying to dislodge something from the throat or to obtain more air. Eventually the chicken, unable to rest on its keel, would fall on its side with movement restricted to a circular crawling motion. An unusual amount of mucus passed from the mouth and nares of birds at death; this symptom was not noticeable in live or moribund birds. Large amounts of urates passed from the anus prior to and after death. Autopsies showed considerable amounts of foods and mucus in the mouths and tracheae of affected chickens. There was slight indication of thyroid enlargement and intramuscular hemorrhage.

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The Brown Wheat Mite in Utah

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The brown wheat mite, *Petrobia latens* (Muller), caused a substantial amount of injury to many thousand acres of dry land wheat in Salt Lake, Juab, Tooele, and San Juan Counties during 1951.

Injury in Salt Lake and Tooele Counties became evident in early May, and was very serious in many fields by May 20. On June 5, some of the Salt Lake County wheat farmers had become concerned enough over the conspicuous mite injury to arrange for parathion spraying of fields by small aircraft. Treatments were started within the next two days, using 1.5 to 2 pints of 25 per cent emulsifiable parathion per acre. Mite kills appeared to be higher when at least 4 to 5 gallons of liquid per acre was applied containing 2 pints of the 25 per cent parathion, than when less liquid was used.

Generally, control efforts were delayed too long in the dry farm fields and little attempt at control was made on irrigated lands. Few chemical control applications were made except in portions of the most severely infested dry farm areas of Salt Lake County where several thousand acres of fall wheat were sprayed once or twice with parathion.

Mite populations often were high and associated with typical foliage discoloration on fall planted dry land wheat and volunteer rye over most of the acreage examined in Salt Lake, Tooele, and Juab Counties. Damage varied from light to negligible in most wheat fields surveyed May 20 to 24, through Box Elder, Cache, Weber, Davis, Utah, Sanpete, and Sevier Counties, but the mite was generally present.

By June 20, much of the dry land wheat in Salt Lake and Tooele Counties had begun to mature. However, mite injury and infestations still were conspicuous on greener foliage. On June 22, spring planted fields of succulent irrigated wheat, barley, and oats were examined in the Jordan district of Salt Lake County. Infestations in many of these fields were fully as severe as had occurred earlier on the dry land wheat fields.

Comparative Insecticidal Value of EPN, Methyl Ethyl Parathion, Methyl Parathion, and Parathion

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Tests to compare the toxicity to insects of tetraethyl dithiopyrophosphate, tetraisopropyl pyrophosphate, and parathion have recently been reported (Bottger & Yerington 1951). Tests with three additional organic phosphorus insecticides—EPN (O-ethyl O-*p*-nitrophenyl benzenethiophosphonate), methyl ethyl parathion, and methyl parathion—in comparison with parathion are reported-herein. Results of preliminary pharmacological work indicate that some of these related compounds are appreciably less toxic than parathion to warm-blooded animals. This characteristic should give them considerable advantage over parathion if they have sufficient insecticidal effect.

The comparisons in this paper are based on dusts containing these insecticides tested against third instars of the celery leaf tier, *Phylctaenia rubigalis* (Guen.), active stages of the citrus red mite, *Paratetranychus citri* (McG.), fourth-instar nymphs of the large milkweedbug, *Oncopeltus fasciatus* (Dall.), and adults of the pea aphid, *Macrosiphum pisi* (Kltb.). All the dusts were made from the purified chemicals, with pyrophyllite as the diluent. Properties of these compounds have been reported by Hall (1950).

In tests against the first three species dusts were applied to plant material or directly to insects in a vacuum chamber. For each test 1 gram of dust was dispersed in the chamber by atmospheric pressure. Tests were replicated five times at three concentrations of the dusts except against the large milkweed bug, and they were replicated seven times at four concentrations. Mortalities of the celery leaf tier and the large milkweed bug were determined 48 hours after treatment, and of the citrus red mite after 72 hours. These data were plotted on log-probit paper to determine the lethal concentrations giving 50 per cent mortality. Results are shown in table 1.

Table 1.—Toxicity of dusts containing parathion and related insecticides to various insects.

Insecticide and Insect	Concentration	Average Mortality After— 48 Hours	72 Hours	LC-50
	P.p.m.	*Per Cent*	*Per Cent*	*P.p.m.*
EPN				
Celery leaf tier	100	77.6	—	50.0
	50	50.2	—	
	30	24.4	—	
Citrus red mite	50	—	72.2	17.2
	10	—	36.4	
	5	—	16.4	
Large milkweed bug	400	81.7	—	178.0
	300	76.8	—	
	200	44.2	—	
	100	35.8	—	
Methyl ethyl parathion				
Celery leaf tier	400	92.6	—	68.0
	200	81	—	
	100	62	—	
Citrus red mite	50	—	77.2	19.0
	10	—	32	
	5	—	12.6	
Large milkweed bug	300	82.5	—	162.0
	200	55	—	
	100	20.2	—	
	50	5.8	—	
Methyl parathion				
Clery leaf tier	400	92	—	190.0
	300	71	—	
	200	63	—	
Citrus red mite	500	—	78	17.0
	100	—	36.2	
	50	—	18.4	
Large milkweed bug	800	61.8	—	660.0
	600	40.8	—	
	400	23.3	—	
	200	4.3	—	
Parathion				
Celery leaf tier	200	92.8	—	76.0
	100	68.4	—	
	50	28.6	—	
Citrus red mite	100	—	88.2	19.8
	50	—	63.6	
	25	—	21.2	
Large milkweed bug	200	80.8	—	125.0
	150	46.7	—	
	100	30.8	—	
	50	11.7	—	

Table 2.—Toxicity of dusts containing parathion and related insecticides to adult pea aphids.

Insecticide	Deposit per Square Centimeter	Average Mortality in 24 Hours	LC-50
	Microgram	*Per Cent*	*P.p.m.*
EPN	0.233	59.2	18.5
	.173	37.8	
	.125	32.8	
	.076	24.2	
Methyl ethyl parathion	.116	77.8	6.5
	.084	62	
	.059	41.8	
	.032	23.4	
Methyl parathion	.024	35.4	2.6
	.018	41.8	
	.011	26.8	
	.007	19.8	
Parathion	.115	86	5.0
	.085	79.4	
	.058	46.2	
	.030	30.6	

In tests against adults of the pea aphid dusts were applied in a settling chamber, and the amount of deposit was determined by weighing an aluminum plate dusted at the same time. Five replications were made at four dosages and the mortalities were determined after 24 hours. The results Table 2 shows.

While methyl parathion was the least toxic of the four compounds tested against the celery leaf tier, and the large milkweed bug (Table 1), it was the most toxic to the pea aphid (Table 2). In fact, against this insect methyl parathion was about twice as effective as parathion and seven times as effective as EPN.

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New Sweetpotato Seedlings That Appear Resistant to Sweetpotato Weevil Attack

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The results of research during the period 1939–46 on the resistance of new sweetpotato seedlings and varieties to attack by the sweetpotato weevil, *Cylas formicarius elegantulus* (Sum.), have been given in a preceding paper by Cockerham & Deen (1947). The studies were continued through 1950 in cooperation with the horticulturists of the Louisiana Agricultural Experiment Station and with the Bureau of Plant Industry, Soils, and Agricultural Engineering. This report includes a discussion of the results obtained with the two most promising sweetpotato seedlings, which are designated as L 187[2] and L 244.

The studies were made on replicated, small field plots and observation plantings consisting of single rows of sweetpotato plants from 30 to 50 feet long and on seedlings and varieties that appeared to possess favorable physiological characteristics, or to represent various percentages of moisture, dry matter, sugar, and carotene content.

During these studies two seedlings generally have been less infested with the sweetpotato weevil than others grown in plots with them, one seedling showing consistently low weevil infestation during 6 years of testing and the other during 3 years of testing. Seedling L 187 was first planted in our experiments in 1942 and was used during 1943, 1945, 1946, 1949 and 1950. Seedling L 244 has been tested during 1948, 1949 and 1950. In 1947 internal cork disease appeared in the breeding stock of the Louisiana Agricultural Experiment Station and no test was conducted that year. Planting was resumed in 1948, but the seedling L 187 was not available for these tests.

In a latin-square test with 5 replicates in 1942, seedling L 187 had 10 per cent infestation and seedling 2×16-39-2 had the highest infestation, 33 per cent. In 1943 no infestation appeared in seedling L 187 and the infestation was too low in the other seedlings for worthwhile comparisons, therefore L 187 was not included in the 1944 test. In field plots with 8 replicates in 1945 there was no infestation in this seedling, but seedling 32-94 (OPF) 43-1 had 10 per cent infestation, which was the highest. In a similar field-plot test in 1946, seedling L 187 had 2 per cent infestation and L 7 had the highest, 28 per cent.

In 1947 there was one plot of seedling L 187 in the field-plot plantings of the Louisiana Agricultural Experiment Station, but no infestation was found in it. Unit I and other selections of Porto Rico occurred 15 times in the plantings, and six of the plots showed infestation. In a replicated field-plot test in 1948, L 244 had 2 per cent of the potatoes infested and L 230 had the highest infestation, 16 per cent. In addition to the infestation in replicated plots, plant breeders of the Louisiana Agricultural Experiment Station reported that seedling L 244 was less infested than the general run of infestation in their plantings during that year. L 187 was not tested in 1948.

In a latin-square planting with eight replicates in 1949, seedling L 187 had 8 per cent infestation, L 244 had 6 per cent, Porto Rico 12 per cent, and L 225 had 33 per cent, the highest in the test. In a similarly replicated planting in 1950, L 187 had 3 per cent of the potatoes infested, L 244 had 6 per cent, Porto Rico had 8 per cent, and Oklahoma 24 had the highest infestation, 29 per cent.

In addition to the latin-square planting in 1950, a small observation planting of two rows 25 feet long of L 187 was made within a planting of Porto Ricos. At harvest time 7 per cent of the potatoes of L 187 were infested, as were also 54 per cent of the potatoes of Porto Rico in the adjacent rows.

A second observation planting was made in another field, using L 187 and Porto Rico for direct comparisons. They were planted in alternate rows 50 feet long, with four replications of each seedling. In this planting L 187 had 16 per cent of infested potatoes and Porto Rico had 39 per cent.

[1] Acknowledgment is made to Julian C. Miller and assistants, Department of Horticultural Research, Louisiana Agricultural Experiment Station, who assisted in this work by supplying the plants or seed used in the experiments and the analysis of the potatoes reported in this paper.

[2] Seedling L 187 was known as 32-10-5 until 1947.

The European Earwig in Erie County, Pennsylvania[1]

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The European earwig, *Forficula auricularia* L., is now well established at North East. Its presence there was first called to the attention of the writer in July 1949 by Mr. C. H. Hayes, Jr. At this time the infestation appeared to be localized around one home. During the summer of 1951 a partial survey showed that the insect was well established over one entire block. The earwig was feeding on vegetables and flowers and was causing annoyance in several homes.

Apparently the earwig has been present in Erie County for some time. In correspondence with Dr. T. L. Guyton the writer has learned that Dr. J. R. Eyer and Mr. C. F. Campbell collected this species along the Southern Shores of Lake Erie in 1926. However, at that time no specimens were preserved for the collection.

As yet, little or no direct control has been attempted by property owners in the infested area at North East. The writer treated the lawn of one property owner in the infested area with dieldrin (4 pounds 25% wettable powder to 100 gallons). One day after the spray was applied a large number of dead earwigs were found on the terrace and in areas adjacent to the house. The treated area was examined 4 days later and no live earwigs were found. However, dead earwigs were readily found under trash piles. In an untreated lawn in the infested area live earwigs were found under trash piles and in other hiding places.

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Determining the Repellent Action of Chemicals to the American Cockroach

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Several good insecticides are now available for the control of cockroaches but little attention has been given to the development of effective repellents. One report by Hazard[1] shows a magnesium oxychloride cement to be repellent. A good repellent would be useful in the control of these pests especially in warm climates where the source of infestation is always present. Most of the search for insect repellents has been confined to those effective against mosquitoes or flies. In this paper a method is described for studying the response of cockroaches to various chemicals. The method detects both repellents and attractants.

The method is based on the roach's habit of hiding in sheltered places away from the light. The insects are given the choice of two shelters one of which is treated on the inside with the candidate chemical. If the chemical is repellent the roaches will be found in the untreated carton or if they are attracted by the chemical they will be found in the treated shelter. Roaches in both shelters indicate the chemical is neutral. After a number of chemicals have been screened those giving a definite response are tested against each other at the same and different dosages. In this way the most effective chemical is identified. Most of the studies reported here were made on the American cockroach, *Periplaneta americana*, but oriental and German roaches were tried in a few tests and found to respond in the same way.

THE ROACH CULTURE.—The colony of American roaches was started and built up with trapped roaches. They were held and reared in large lard cans which had been modified by replacing the bottoms with hardware cloth. They were set in round galvanized iron pans 2 inches deep on about 1 inch of sawdust some of which was also placed inside the lard cans to cover the hardware cloth. The sawdust has a two-fold purpose: It provides an attractive place for the female to lay her eggs and it absorbs moisture thus reducing mold growth on the inside of the containers. The lard cans were provided with shelters made from about eight masonite discs held apart by three-fourths inch spacer blocks. The blocks and the discs each had a hole in the center. A bolt through the discs and spacers held the shelters firmly as a unit. Three legs about an inch long were used to hold the bottom discs above the sawdust. The food[2] and the water were placed on the top discs. The center 6 inches of the lard can lids were replaced by the fine mesh screen.

Table 1.—Ten of the best repellents chosen from over 200 compounds tested against the American cockroach. The results are the average of four readings expressed as the nearest whole number.

Cpd. No.	Name	Position of Roaches in Cartons		
		Treated	Untreated	Outside
A.	5-Chloro-4-amino-2,6-dimethylpyrimidine		10	
B.	Butadiene-furfural copolymer		10	
C.	*tert*-Butylsulfenyl thiocyanate	1	7	2
D.	Isopropylsulfenylpiperidine		9	1
E.	O-Ethyl-S-*tert*-butylsulfenyl xanthate		10	
F.	O-Ethyl-S-*tert*-butylthiosulfenyl xanthate		10	
G.	N,N-Dimethyl-*tert*-butylsulfenyl dithiocarbamate		10	
H.	1,2,3,4-Tetrachlorobutane		9	1
I.	Acetophenone		10	
J.	Cumene isopropyl peroxide		10	

Each time roaches were needed all those in one cage were anesthetized with carbon dioxide. They were sorted and the cage was cleaned before using it again. Starting from hatching eggs, a certain age range was kept in each cage. Only four months were required to obtain adult roaches at 82°F. when food and water was kept before them at all times.

APPARATUS AND METHOD.—The apparatus consisted of screened cages to confine the roaches and two shelters in which they could hide. The cages were 10 by 10 by 18 inches. They consisted of a wood frame with screen on three sides, solid wood ends, and a sliding masonite panel on the back. The two identical shelters were made from inverted, lidless, one-pint ice cream cartons with notches cut in the rims large enough to allow roaches to enter. Food and water were provided in the cage because well-fed roaches hide in the shelter of their choice and do not roam about the cage in search of food.

The notched inverted cartons were placed on the bottom which is one of the screened sides of the cage. The number of roaches in each carton could then be determined easily by carefully removing the cage from its shelf and holding it high enough to see up into the cartons.

The cartons were treated on the inside with an acetone solution of the candidate repellent. At first five ml of a 1 per cent solution was used giving 50 mg of chemical. This was placed in the carton which was rotated until the entire inner surface had been coated. Most of the acetone evaporated quickly but an hour was allowed for it to dry completely. This dosage was sometimes reduced to 10 mg. of chemical which was also applied in five ml of acetone.

Ten roaches, usually young adults, were placed in the cage with the shelters. They were anesthetized with carbon dioxide for ease in handling. The cage with its contents was placed on a wrapping paper covered shelf. The roaches did considerable investigating during the first day. On the second day they had generally definitely chosen the preferred shelter. The tests were made in a room lighted with fluorescent lights which were on 16 hours and off 8 hours. The tests were usually read once each day for 5 days, but three readings on succeeding days should be sufficient.

Longer observations than five days gave some indication of the permanence of the chemical. It was soon found, however, that their own odor is a powerful attractant for roaches. Any carton previously inhabited by roaches was preferred to a clean one. In some tests "roachy" cartons were treated with a chemical found to be a good repellent. If the repellent was good it overcame the attraction of the roachy odor.

Several chemicals were found to be attractive. A high boiling amine was attractive enough to be used as a bait. A trap made from a quart fruit jar and a paper cone was baited with this amine and it caught many roaches from a natural infestation.

[1] Soap and Sanitary Chemicals 21(4): 129–35, 157 (1945.)
[2] Ralston Purina Dog Checkers.

Table 2.—Comparative repellent action of the 10 compounds showing good activity in preliminary tests against the American roach. Results are averages of four readings expressed as the nearest whole number.

Cpd. No.	Name	Compound Compared No.	Position of 10 Roaches: Shelter Treated With Compound Listed	Compared	No shelter
A.	5-Chloro-4-amino-2,6-dimethylpyrimidine	B	9		1
		G	8		2
B.	Butadiene-furfural copolymer	A		9	1
		C	9		1
		D		9	1
		E	1	2	7
		F	1	2	7
		G		9	1
		J			10
C.	*tert*-Butylsulfenyl-thiocyanate	B		9	1
		F	8		2
		J	9		1
D.	Isopropylsulfenyl-piperidine	B	9		1
		H	8	1	1
		J	8	1	1
E.	O-Ethyl-S-*tert*-butysulfenyl xanthate	B	2	1	7
		F	3	1	6
		G	2		7[1]
		H	1	1	8
		J	7		3
F.	O-Ethyl-S-*tert*-butyl-thiosulfenyl xanthate	B	2	1	7
		C		8	2
		E	1	3	6
		J	3	1	6
G.	N,N-Dimethyl-*tert*-butylsulfenyl dithiocarbamate	A		8	2
		B	9		1
		E		2	7[1]
		F		3	7
		H		1	9
		I		6	4
		J	2		8
H.	1,2,3,4-Tetrachloro-butane	D	1	8	1
		E	1	1	8
		G	1		9
		J	5	1	4
I.	Acetophenone	G	6		4
		J	10		
J.	Cumene isopropyl peroxide	B			10
		C		9	1
		D	1	8	1
		E		7	3
		F	1	3	6
		G		2	8
		H	1	5	4
		I		10	

[1] One roach died.

Results of Tests.—Of the more than 200 compounds tested, most showed little or no effect on the roaches. Some were attractive but more were repellent. Table 1 shows some typical results. After the preliminary screening the following compounds[1] were found to be repellent:

A. 5-Chloro-4-amino-2,6-dimethylpyrimidine
B. Butadiene-furfural copolymer (2,3,4,5-bis(Δ^2-butenylene)tetrahydrofurfural)[2]
C. *tert*-Butylsulfenyl thiocyanate
D. Isopropylsulfenylpiperidine
E. O-Ethyl-S-*tert*-butylsulfenyl xanthate
F. O-Ethyl-S-*tert*-butylthiosulfenyl xanthate
G. N,N-Dimethyl-*tert*-butylsulfenyl dithiocarbamate
H. 1,2,3,4-Tetrachlorobutane
I. Acetophenone
J. Cumene isopropyl peroxide

As shown in table 2 these 10 compounds were then tested against each other in various combinations. It was found that the butadiene-furfural copolymer and cumene isopropyl peroxide were the most effective repellents. A further investigation of other peroxides and hydroperoxides was then made and nearly all are repellent. The butadiene-furfural copolymer is a high boiling compound with little odor and is stable over long periods. A practical test in a photographic dark room inhabited by roaches kept them away for more than six weeks.

Summary.—A method is described for the determination of the repellent and attractant action of chemicals to cockroaches. The chemicals were deposited on the inside of shelters which were placed in large cages containing the roaches in a lighted room. The light drives the roaches to seek shelter and to choose the one of the shelters least repellent to them. Over 200 chemicals were screened and those showing a repellent action were tested against each other. Organic peroxides and butadiene-furfural copolymer show a high degree of repellency. The butadiene-furfural copolymer is quite stable and appears to have considerable practical value as a roach repellent.

[1] Some of these are covered by pending patent applications.
[2] Recent tests have shown butadiene furfural copolymer is also repellent to mosquitoes, house flies and stable flies.

Two-spotted Lady Beetles Biting Man

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Two-spotted lady beetles, *Adalia bipunctata* L., are usually considered to be beneficial insects feeding largely upon plant lice. Stiles & Hassal in their "Key Catalogue of Insects of Importance in Public Health," Hygienic Laboratory Bulletin 150, 1928, do not mention this beetle as biting man. The following note reports their doing so. During the latter part of September 1951 large numbers of these beetles were concentrating prior to going into hibernation. At this time while working in their vicinity many of the insects in their fortuitous flights alighted on my body and upon several occasions bit strongly enough to be unpleasant. The natural reaction following the bite was to brush the insect off hence they did not remain in one position long enough to actually bite through the skin although there is no reason to suppose that they were not capable of accomplishing this.

Effect of Iodine on the Longevity of Caged Bees[1]

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Some Colorado beekeepers have been feeding various concentrations of iodine to their bees in an attempt to control European foulbrood. Since little is known regarding the effect of iodine on honeybees, tests were undertaken at Fort Collins during the winter of 1949–50 to determine the effect of various concentrations of iodine on the longevity of caged adult bees.

The bees were obtained from a colony that had been brought into the laboratory. The bees were taken off the frames by hand and placed in queen cages. Ten bees were placed in each cage. The bees were fed by punching holes in the top of a screw-capped vial and inverting the vial. Their food consisted of sugar sirup containing one part sugar and one part water. A seven per cent concentration of iodine dissolved in eighty-five per cent alcohol was used. The tincture of iodine was added directly to the sugar sirup. The sirup was changed daily to prevent excessive mold development. A vial of water was furnished each cage. The cages were placed in a cabinet in a dark room. The temperature of the cabinet varied from 79° to 89° F., while the relative humidity ranged from 30 to 35 per cent.

Daily counts of the number of dead bees were made, and the bees found dead were considered to have died halfway between observations. In both Experiment A and Experiment B 10 cages received each treatment. The numbers used in the analysis of variance were the mean average length of life of the bees in each cage.

Experiment A was started after the colony had been inside 7 weeks, while Experiment B was started after the colony had been inside 16 weeks. The different starting times of the two experiments may account for the differences in the length of life of the bees.

The results of feeding various concentrations of iodine are given in table 1. An analysis of variance study was made of the data with the aid of Nellie Landblom, research statistician for the Colorado Agricultural Experiment Station.

In both tests the longevity of the bees decreased as the concentration of the iodine increased. However, there was no significant difference between the longevity of bees fed one part per million iodine and the longevity of bees fed no iodine.

Bees fed 10 parts per million of iodine showed a significant decrease in length of life in Experiment A, but no significant decrease in Experiment B, when compared to bees fed no iodine.

In both tests a concentration of 100 parts per million of iodine resulted in a highly significant reduction in length of life of adult bees when compared to bees fed no iodine. The decrease in length of life was also significant when compared to bees fed weaker concentrations of iodine.

Bees fed 1000 parts per million of iodine showed a highly significant decrease in longevity when compared to check bees in both experiments, as well as significant or highly significant decreases when compared to bees fed lighter concentrations of iodine.

Apparently large amounts of iodine in sugar sirup shortened the life of caged adult bees. The higher the concentration of iodine used, the greater was the decrease in the length of life of the bees. Since several beekeepers received no observed benefit from feeding iodine to European foulbrood diseased colonies during the spring of 1950, it might be advisable for beekeepers to refrain from feeding high concentrations of iodine to honeybees.

Table 1.—The average length of life of caged adult bees fed different concentrations of iodine in sugar sirup.

TREATMENT	AVERAGE LENGTH OF LIFE OF BEES IN DAYS IN:	
Parts per Million of Iodine	Experiment A	Experiment B
0 (check)	31.09	18.46
1	31.05	17.24
10	25.79[1]	16.71
100	15.09[2]	10.74[2]
1000	4.26[2]	5.76[2]
Min. diff. required for sign.		
At the 5 per cent level	4.80	4.80
At the 1 per cent level	6.41	6.41

[1] Significantly different from check at 5 per cent level.
[2] Significantly different from check at 1 per cent level.

[1] Scientific Journal Series No. 483, Colorado Agricultural Experiment Station.

Insecticide Sprays as a Probable Control of "Sterility" in Blackberries

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Blackberries grown in this area have for many years been affected by a condition characterized by the partial or complete failure of the berries to develop normally—a so-called sterility condition. The plants blossom freely, but fruit development is arrested soon after flowering. Affected berries remain small and green, and eventually dry up, or there may be partial development wherein one or more drupelets attain normal size and color. This condition varies greatly from season to season but in bad years a high percentage of the crop may be involved.

As a result of what was learned about tarnished

Table 1.—Results of spray treatments in the prevention of the "sterility" condition in blackberries.

MATERIAL AND RATE PER 100 GALLONS		VARIETY	NUMBER BERRIES EXAMINED	PER CENT INJURED
DDT	2 lbs.	Erie	916	6
Check		Erie	1287	73
DDT	2 lbs.	Merserau	816	6
Check		Merserau	1006	62
Dieldrin	0.5 lb.	Eldorado	329	2
Check		Eldorado	6041	47
Dieldrin	0.5 lb.	Brewer	1245	20
Check		Brewer	1004	66

plant bug injury to strawberry fruits in recent studies (unpublished), it was considered possible that this insect or some other species might be responsible for the blackberry fruit condition. Consequently, spray applications were made to the Station's 2-acre variety planting in 1951 using DDT and dieldrin. No formal experiment was set up, but some rows were left untreated to serve as checks. Using a standard high pressure orchard sprayer, the treatments were applied May 10, or about a week before the blossoms opened. The condition of the fruit in treated and untreated areas at harvest time, July 23 and 24, is summarized in Table 1.

That the DDT and dieldrin spray treatments effected a great reduction in the number of "sterile" fruits seems clearly evident from the data. Which of several possible insect species was controlled by the spray is not now known with certainty, but the most likely suspect is the tarnished plant bug. It was abundant in the plantings at treatment time and, furthermore, the species is known to injure buds and fruits of many other plants. Evidence that this sterile fruit condition in blackberries is insect-caused is shown by the fact that blossoms clusters bagged for breeding purposes seldom, if ever, have shown this condition. Experiments are planned, of course, to establish definitely, if possible, the cause of the trouble in 1951.

It has seemed worthwhile to place the outcome of these preliminary efforts on record now for the benefit of those who may wish to use such spray treatments on a trial basis in 1952.

Aldrin, DDT, Dieldrin and Other Insecticides for Control of Imported Cabbageworm

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The imported cabbageworm, *Pieris rapae* (L.), is one of the most destructive insects on cabbage in Manitoba. Although a few adult butterflies usually are present in late spring, it is not until well along in the summer that the first larvae occur on cabbage grown in garden and field. In addition to the imported cabbageworm which was abundant in 1951, aphids and thrips were present also on the cabbage plants but were not sufficiently numerous to be very destructive. Although the diamondback moth, *Plutella maculipennis* (Curt.) frequently occurs on cabbage in Manitoba, it was conspicuously absent in 1951 as only a comparatively few larvae were seen throughout the summer. Flea beetles were not present on the plots used in this work, nor was the cabbage looper, *Trichoplusia ni* (Hbn.).

In the past, many different insecticides have been used to control cabbage infesting insects. In late years DDT has given good control for most of them. Dills & Odland (1948) found that DDT gave the best control of cabbage caterpillars consisting of the imported cabbageworm *Pieris rapae* (L.) and the cabbage looper *Trichoplusia ni* (Hbn.) among fourteen different insecticides used in the form of dusts. Our project was undertaken to compare some of the newer insecticides with DDT for the control of the imported cabbageworm.

METHOD.—Plots were laid out early in the year for this project and seeded with Danish Ballhead cabbage. Each of the three replicated plots consisted of eight rows approximately 97 feet long and spaced 3 feet apart. Three rows therefore occupied approximately one-fiftieth of an acre. The two outside rows of each plot were guard rows which were not used to obtain data for this paper. The other six rows in each of the three plots were sprayed on August 3 when the heads had just started to form and again on August 28, 1951. Aldrin, DDT, dieldrin, Test Material 1[1] and Test Material 2[1] were each used on one row previously selected at random from each plot. The sixth row was used as a check. Each of the five insecticides used was in the form of an emulsifiable concentrate. The aldrin, dieldrin, TM-1 and TM-2 were each used at the rate of two ounces of actual toxicant to 40 imperial (50 U. S.) gallons of water. The DDT[2] was used at the rate of 6.66 ounces of actual toxicant to the same amount of water. In each instance two imperial gallons of spray were applied to the three replicated rows which is at the rate of 100 imperial gallons per acre. To each two gallon lot of spray one heaping teaspoonful of "surf," a household detergent, was added as a wetting agent to make the spray spread over and remain on the waxy cabbage leaves. The spray was applied with a hand operated three U. S. gallon compressed air sprayer.

RESULTS.—At approximately weekly intervals beginning Aug. 7, which was four days after the first sprays had been applied, five heads selected at random from each row were examined for larvae of the imported cabbageworm. Table 1 shows the total number of larvae on the 15 heads which had been sprayed with the respective insecticides. The number of larvae present on 15 heads from the three check rows is also indicated for each of the six dates. The total number of living larvae for the six counts made on 90 heads for the season as shown in the last column of table 1 is an indication of the effectiveness of the respective insecticides. DDT and TM-1 were most effective. These were followed in descending order by TM-2, dieldrin and aldrin. It will be noted that the larval population increased progressively up to August 27. On August 28 the second spray was applied. After this date the larval population decreased to a marked degree especially on plants sprayed with DDT and TM-1. The aldrin sprayed plants were an exception.

Table 1.—Number of imported cabbageworm larvae counted at different dates on random samples of 15 cabbage heads, five from each of the three replicated rows, treated respectively with five insecticides.

INSECTICIDE	DATES OF COUNTS						TOTAL
	Aug.				Sept.		
	7	13	20	27	4	10	
DDT	4	1	17	82	11	6	121
TM-1	6	0	18	105	9	13	151
TM-2	7	8	32	114	49	93	303
dieldrin	13	23	33	136	110	78	393
aldrin	49	31	67	173	296	420	1036
check	88	62	88	187	298	546	1269

[1] Test Material 1 and Test Material 2 are Hyman compound 269 and Hyman compound 711 respectively. TM-1 is a stereoisomer of dieldrin and chemically is 1,2,3,4,10,10-hexachloro-6, 7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-1,4,5,8-endo-endo-dimethanonaphthalene. TM-2 is a stereoisomer of aldrin and chemically is 1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a-hexahydro-1,4,5,8-endo-endo-dimethanonaphthalene.

[2] This was purchased from the trade under the name of "Sapho 25 per cent DDT for water emulsion" and contained 2.5 pounds of DDT per imperial gallon. It was manufactured by The Kennedy Manufacturing Co., Montreal.

Table 2.—The effects of the five different insecticides on the average size of the cabbage heads when harvested.

INSECTICIDE	HEADS HARVESTED	POUNDS OF HEADS HARVESTED	AVERAGE POUNDS PER HEAD	PER CENT INCREASE OVER CHECK
TM-1	116	447	3.85	57.78
TM-2	104	397	3.81	56.14
DDT	114	411	3.60	47.54
dieldrin	122	409	3.35	37.29
aldrin	116	369	3.18	30.32
check	107	262	2.44	0.0

On October 6 the sprayed rows of cabbage were harvested and trimmed for market. Table 2 shows the number of heads in the three rows on which each of the insecticides had been used as well as the number of heads in the three check rows. Table 2 also shows the total weight of cabbage harvested for each three rows, the average weight per head and the percentage increase in weight per head over the check rows for each insecticide used. It will be noted that cabbage sprayed with TM-1 were the largest. Those sprayed with TM-2 were the next largest and those sprayed with DDT were the next in size. These were followed by those sprayed with dieldrin while those sprayed with aldrin were the smallest.

The condition of the cabbage harvested after the various treatments had been applied was also noted at the time of harvesting on October 6. Neither the trimmed heads nor the outer leaves of plants sprayed with either DDT or TM-1 showed any evidences of having been chewed by the larvae of the imported cabbageworm. Trimmed heads from rows sprayed with TM-2 were all free from injury and were marketable also, but some of the outer leaves on the plants showed evidences of the previous presence of larvae. Four heads from the rows sprayed with dieldrin showed holes and were not marketable. The remainder of the heads were marketable but there were some holes in the outer leaves left in the field. A number of trimmed heads from the aldrin sprayed rows were not marketable due to the presence of holes while the outside leaves were chewed quite badly. The heads from the check rows were for the most part unmarketable due to injury while the outside leaves were very badly chewed.

SUMMARY.—1. Using size of harvested cabbage head as a criterion of the usefulness of the respective insecticides, they ranked in the following descending order: TM-1, TM-2, DDT, dieldrin and aldrin.

2. Basing our evaluation on their effectiveness in reducing the population of the imported cabbageworm throughout the summer the insecticides may be placed in the following descending order: DDT, TM-1, TM-2, dieldrin and aldrin.

3. From the standpoint of marketability, namely freedom from injury at the time the heads were harvested, the insecticides would be placed as follows: DDT, TM-1 and TM-2 were equally effective. These are followed by dieldrin and aldrin respectively.

4. Any one of DDT, TM-1 or TM-2 used at the concentrations indicated in this paper at two applications seemed to protect cabbage from serious injury from the imported cabbageworm in 1951 at Winnipeg. This applies especially to DDT and TM-1.

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Insecticide Treatments for the Corn Earworm on Certain Flower Crops

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The corn earworm, *Heliothis armigera* (Hbn.), is known to be injurious to a large number of annual and perennial flowers (Weigel & Baumhofer, 1948), and in California it occasionally causes serious losses in commercial flower fields.

GERBERIAS.—In 1947 insecticide tests were made in cooperation with a grower who had been having serious losses in seed production from caterpillars attacking the maturing flower heads of *Gerberia jamesono*. Three species of moths reared from larvae collected during the experiment were identified as *Heliothis armigera* (Hbn.), *Homoeosoma mucidellom* Rag. and a *Platynota* sp. Of these, the larvae of *H. armigera* were most numerous and probably were responsible for most of the damage.

The insecticides were applied as dusts and treatments were begun when the first damaged flowers were found. Including the checks, there were four treatments replicated 4 times. The plots were 12 feet wide, 30 feet long, and were arranged in a latin square design. To minimize the drift of dust from one plot to another, untreated areas 6 feet wide were left on each side of each plot.

The dusts were applied on July 19 and 24, and August 6 at approximately 100 pounds per acre. A small power duster with four outlets on a wheelbarrow-type mount was used. Since an overhead

Table 1.—Results of insecticide treatments for the control of *Heliothis armigera* (Hbn.) and two other species of moths attacking *Gerberias*.

MATERIAL	PERCENTAGE OF DAMAGED FLOWER HEADS	
	JULY 24 TO AUGUST 5	AUGUST 6 TO AUGUST 27
DDT, 5% dust	5.3	0.6
Toxaphene, 5% dust	4.7	0.9
Chlordane, 5% dust	4.2	0.6
Check	12.9	11.3
Minimum significant difference:		
5% level	2.6	3.9
1% level	3.9	5.9

Table 2.—Effect of insecticide treatments on *Heliothis armigera* (Hbn.) on field grown asters.

MATERIAL[1]	DAMAGED FLOWERS PER PLOT (AVERAGE)
Toxaphene 60% emuls. conc., 1.25 lbs. per 100 gallons	4.3
Toxaphene, 10% dust	1.0
Chlordane 40% emuls. conc., 1 lb. per 100 gallons	1.0
Chlordane 40% emuls. conc., 2 lbs. per 100 gallons	1.7
Benzene hexachloride 12% wettable powder, 0.24 lb. gamma isomer per 100 gallons	14.7
Benzene hexachloride dust, 0.75% gamma isomer	15.7
Check	73.3
Mean significant difference:	
5% level	28.3
1% level	39.6

[1] For sprays the amounts given are in terms of the active ingredient.

sprinkling system was employed, the applications were made the day after watering so that the dusts would remain on the plants as long as possible before being washed off.

The effectiveness of the insecticide treatments was determined on the basis of the percentage of damaged flower heads. Mature flower heads were collected every 2 or 3 days and the total number, and the number damaged, were recorded for each plot.

Results are shown in table 1. After August 5 there was a marked decrease in the number of damaged flower heads in the treated plots and after August 27 there was very little injury in any of the plots. Differences between the checks and the insecticide treatments were highly significant. There were no significant differences among the insecticide treatments.

Results are shown in table 2. More damaged flowers were found in the benzene hexachloride plots although analysis of the data did not indicate significant differences among the insecticide treatments. Highly significant differences occurred between the checks and all insecticide treatments.

ASTERS.—In 1949, in an experiment conducted for the control of leaf miners in asters, data was obtained on the effectiveness of the various insecticide treatments against *Heliothis armigera*.

The experiment consisted of seven treatments replicated 4 times in a randomized block design. However, block 1 was earlier than the others and the flowers had been cut when the infestation developed. Plots were 10 rows wide and 40 feet long. Counts were made by examining the flowers and opening buds and recording the number damaged in the 4 center rows of each plot.

Between August 29 and September 19 there were four spray applications and nine dust applications. The sprays were applied with a small power sprayer at 300 pounds pressure using a gun with a number 3 disc. The dusts were applied with a rotary hand duster at 35 to 45 pounds per acre. The asters were watered every 2 to 3 days with an overhead sprinkling system. In general, the plots were dusted after every watering and sprayed after every other watering.

DISCUSSION AND CONCLUSIONS.—With both asters and *Gerberias* only the buds and flowers were damaged as no foliage injury was noted. Only occasionally were larvae found in the buds and flowers during the daytime. The habit of the larvae of moving around may have been largely responsible for the control obtained since it would be difficult to reach them inside the buds or flowers with sprays or dusts.

The frequent insecticide applications were made to the asters because of the heavy leaf miner infestation. While fewer applications were made to the *Gerberias*, these also were watered less frequently than the asters.

From the results of the tests it appears that damage to flower crops from *Heliothis armigera* (Hbn.) may be materially reduced by the application of sprays and dusts containing toxaphene, chlordane or DDT. On asters, benzene hexachloride did not appear to be as effective as chlordane and toxaphene although analysis of the data did not indicate significant differences between the benzene hexachloride treatments and the chlordane and toxaphene treatments.

LITERATURE CITED

Weigel, C. A., and L. G. Baumhofer, 1948. Handbook on insect enemies of flowers and shrubs. U.S.D.A. Misc. Pub. No. **626.**

Residual Effect of Chlordane on Crabgrass when Applied to Lawns for Control of Sod Webworm[1]

ROY D. SHENEFELT, *Department of Entomology, University of Wisconsin, Madison*

During 1949 a sod webworm, *Crambus* sp., was very abundant on lawns in Central Wisconsin. A DDT spray, 1.5 lbs. of 50 per cent W.P. in 25 gals. of water, was used on July 24 with excellent control resulting. The larvae came to the surface and died within a few days. On the same day, a strip was sprayed with chlordane emulsion at approximately 10 lbs. actual per acre to test the effectiveness of chlordane against the webworm. This insecticide also effectively controlled the insect. Neither insecticide appeared to affect the grass adversely, *i.e.*, there was no browning of grass as a result of the spraying.

In midsummer of 1950, observations of the plots sprayed in 1949 showed that the strip sprayed with chlordane was much greener than the area sprayed with DDT. Examination revealed that the difference was due to the absence of crabgrass in the chlordane treated strip. This same strip continued to remain practically free of crabgrass during the 1951 season.

During 1951 a series of three latin squares involving six different treatments representing the components of the emulsion used in 1949, a chlordane wettable powder and checks were established to determine whether the chlordane itself or some other ingredient or combination in the emulsion caused the disappearaace of the crabgrass. To test the effect of time of application, treatments were made June 21, July 20 and August 13.

[1] Approved for publication by the Director of the Wisconsin Agricultural Experiment Station.

Periodic examinations throughout the remainder of the season showed no essential differences between check and treated plots and it was concluded that the effect observed had to be on either the seed or very young plant.

Very recently B. H. Grigsby reported inhibition of crabgrass germination by chlordane in greenhouse tests. He stated that "further trials over a longer period of time are needed to determine whether chlordane will inhibit crabgrass germination in treated sod."

With the time of effect established and a different carrier used by Grigsby showing that it is actually chlordane which is responsible, the purpose of this note is to record the fact that treatment with chlordane emulsion at 10 lbs. actual per acre will inhibit the development of crabgrass in lawns for at least two seasons following application to lawns on Plainfield sand in Wisconsin.

LITERATURE CITED

Grigsby, B. H. 1951. The Use of Chlordane for the Control of Crabgrass (A Preliminary Report). Quarterly Bull. Mich. Agr. Exp. Sta. **34**(2): 158–61.

Insecticidal Control of Grasshoppers[1]

R. L. HANNA AND J. C. GAINES, *Texas Agricultural Experiment Station, College Station*

Tests of insecticides for the control of the differential grasshopper, *Melanoplus differentialis* Thos., conducted at this station in 1951 were a continuation of investigations begun in 1947. Median lethal doses of all the insecticides used in the 1951 tests except heptachlor had been worked out previously in laboratory tests and had proved effective in field experiments (Gaines & Dean (1949); Gaines & Hanna (1950)).

The experiment reported here was carried out to obtain more information about the dosages required for adequate control as well as additional comparisons of the efficiency of the different insecticides.

A split plat latin square (5 by 5) experiment was laid out in a small pasture. Each whole plat was 0.2 acre in size. These whole plats were split lengthwise and one of the splits or sub-plats was selected at random to receive the lower dosage of an insecticide while the other received the higher dosage. Each row of plats was separated from the next row by an untreated strip 50 feet wide which served as a reservoir for reinfestation. This provided for comparisons of four insecticides at two dosage levels with check or untreated plats. Each treatment was replicated 5 times.

A compressed air sprayer mounted on wheels was operated at 40 pounds pressure to disperse the spray through hollow cone nozzles spaced 20 inches apart on the boom. The spray was applied at approximately 5 gallons per acre. The spray tank was weighed before and after each application to determine the exact amount of spray applied for each treatment. Infestation data were obtained by making 100 sweeps in each sub-plat with a 16 inch sweep net. An initial record was made before the application of insecticides in order to be able to evaluate the treatments on the basis of percentage original infestation living after treatment. Records were made at 4-day intervals for a period of 20 days following the application. One-half inch of rain fell on the sixth day after the application.

Analysis of the average percentage of live hoppers during the 20 day period showed dieldrin applied at an average rate of 0.09 pound active ingredient per acre to be significantly more effective than aldrin at 0.12 pound, heptachlor at 0.31 pound or toxaphene at 1.12 pounds per acre. The difference between the lower and higher dosage of insecticides was not significant. This was probably because the mobile nature of the grasshopper population tended to equalize the infestation in each pair of adjacent subplats. It will be noticed that the lower dosage of dieldrin did not remain as effective as the higher dosage during the latter part of the test period. Dieldrin exhibited a longer residual toxicity than did either of the other insecticides tested.

LITERATURE CITED

Gaines, J. C., and H. A. Dean. 1949. Comparison of sprays and dusts for grasshopper control. JOUR. ECON. ENT. **42**(6): 956.

Gaines, J. C., and R. L. Hanna. 1950. Grasshopper control. JOUR. ECON. ENT. **44**(1): 116.

[1] Technical contribution No. 1550 Texas Agricultural Experiment Station.

Table 1.—Grasshopper infestation following treatments as indicated at College Station, Texas.

TREATMENT	POUNDS ACTIVE INGREDIENTS PER ACRE	PER CENT LIVE HOPPERS DAYS AFTER APPLICATION 4	8	12	16	20	AVERAGE	AVERAGE OF BOTH DOSAGE LEVELS
Dieldrin	.16	4.3[1]	9.7	8.3	14.8	26.1	12.7	10.4
	.12	2.8	6.5	7.2	9.1	14.7	8.1	
Aldrin	.10	17.5	23.0	11.0	14.3	25.8	18.3	19.6
	.15	19.9	14.8	14.7	17.9	37.9	21.0	
Heptachlor	.22	13.8	14.0	15.4	20.8	34.5	19.7	19.5
	.40	13.4	11.9	13.8	23.4	34.2	19.4	
Toxaphene	.81	24.5	29.2	30.9	23.5	42.5	30.1	26.0
	1.44	11.0	12.3	13.5	29.7	42.9	21.8	
Check	—	100.4	83.2	75.9	54.1	57.5	74.2	75.3
	—	110.1	87.0	67.3	63.2	54.2	76.4	

[1] Average Population on 5 Plats.

EDITORIAL

Legislative Control of Pesticide Use

No doubt there are individuals who, upon reading this title, will raise the question, "Do we need any type of regulation or legislative control of pesticide use?" If we are to judge the actions of man on the basis of his past performance, apparently we do.

We are told that our race began with two individuals, Adam and Eve, and that they enjoyed almost complete freedom with only one act forbidden. Fifty per cent of the population, Eve, disobeyed the law, and then was also charged with contributing to the delinquency of the other 50 per cent, Adam. Centuries later the Ten Commandments were laid down to govern the conduct of man, but again, history records man's failure. Still later the Master Himself proclaimed a doctrine of "Love thy neighbor as thyself," which man translated to read "Do unto others as you would that they should do unto you."

If all mankind would observe the so-called Golden Rule, no additional rules, regulations, or laws would be required. But, alas, one needs only to observe the conduct of his friends, his neighbors, and his associates to determine for himself whether or not some form of regulation is desirable or necessary. The plain fact is that we do need some sort of rules and regulations governing practically all phases of our daily activities. Pest control is no exception. Past history tells us that, without regulations, some individuals will carelessly or maliciously violate even the most widely accepted standards of safety. If you were to apply the Golden Rule to certain unscrupulous peddlers and careless or indifferent food producers, you would be obliged to do your level best to poison them.

By and large, no one objects to reasonable regulation of his activities through legislation or otherwise, but most Americans are not ready to accept dictatorship in any manner, shape, or form. In reality the question boils down to how much regulation is reasonable, safe, sound, and necessary. We now have two rather broad, basic, federal statutes that afford the public a very large and perhaps adequate degree of protection. I might add that scientists, pesticide manufacturers, agricultural leaders, and others interested in pest control contributed to the formulation of these laws and urged their adoption by Congress. Incidentally, scientists and pesticide manufacturers may be poisoned just as easily as any rural family in North Dakota or society matron in Washington, D. C., and they value their skins just as highly.

The Federal Insecticide, Fungicide, and Rodenticide Act of 1947 authorizes the Secretary of Agriculture to regulate the movement and use of economic poisons (pesticides) through the registration and labeling requirements of the Act. The labeling provisions of the Act specify in considerable detail what must appear on the label or labeling. For example, Section 2 contains among others the following provisions:

"u. The term 'misbranded' shall apply . . . (2)(c) if the labeling accompanying it does not contain directions for use which are necessary and if complied with adequate for the protection of the public; . . . (d) if the label does not contain a warning or caution statement which may be necessary and if complied with adequate to prevent injury to living man and other vertebrate animals, vegetation, and useful invertebrate animals; . . . (g) if in the case of an insecticide, fungicide, or herbicide when used as directed or in accordance with commonly recognized practice it shall be injurious to living man or other vertebrate animals, or vegetation, except weeds, to which it is applied, or to the person applying such economic poison."

Section 4 of the Act provides that:

"a. Every economic poison which is distributed, sold, or offered for sale in any Territory or the District of Columbia, or which is shipped or delivered for shipment from any state, territory, or the District of Columbia to any other state, territory, or the District of Columbia, or which is received from any foreign country shall be registered with the Secretary."

The enforcement of the Act is simplified by the provision for prohibiting the shipment of a product in interstate commerce until it has been registered with the Insecticide Division of the U. S. Department of Agriculture.

To obtain registration of his product, an applicant must file with the Secretary a statement giving his name, the name of the economic poison involved, a copy of the proposed label, and a complete statement of all claims to be made for the product, including directions for use, necessary precautions, etc.

Obviously, in view of the labeling requirements already cited, the supporting evidence submitted with the application must establish beyond any reasonable doubt that when the product is used in accordance with directions or commonly recognized practice, it will not be injurious to man, other vertebrate animals, vegetation, the person applying such poisons, or endanger the public health. If in processing an application the Secretary finds that all provisions of the law have been adequately met, a certificate of registration is issued. If, on the other hand, in the opinion of the Secretary all of the requirements of the law are not fulfilled, he will advise the applicant wherein he has failed to comply with certain provisions of the Act and give him an opportunity to supply additional data or make such changes as are necessary. However, the Act further provides that "if, upon receipt of such notice, the registrant insists that such corrections are not necessary and requests in writing that it be registered, the Secretary shall register the article under protest. . . . " This provision does not constitute a serious loophole in the law. On the contrary, it was a wise provision by Congress to prevent any Secretary, so minded, from exercising unjustifiably arbitrary, dictatorial powers. In this connection it might be pointed out that to date over 30,000 pesticides have been registered, and an extremely small number, less than a dozen, have been registered under protest. Furthermore, matters of public health or safety to the consumer were not a point of controversy in any of the protest registrations.

The Federal Food, Drug, and Cosmetic Act of 1938 in effect regulates the use of pesticides by prohibiting the movement in interstate commerce of adulterated and misbranded foods. The spray residue provisions of the Act are contained in Sections 402 and 406, and the full import of the provisions that are made can be obtained only by considering these two Sections together. The pertinent provisions of Sections 402 and 406 provide:

"Sec. 402. A food shall be deemed to be adulterated—(a)(1) if it bears or contains any poisonous or deleterious substance which may render it injurious to health; . . . (a)(2) if it bears or contains any added poisonous or added deleterious substance which is unsafe within the meaning of section 406; . . . "

"Sec. 406. (a) Any poisonous or deleterious substance added to any food, except where such substance is required in the production thereof or cannot be avoided by good manufacturing practice shall be deemed to be unsafe for purposes of the application of clause 2 of section 402(a); but when such substance is so required or cannot be avoided, the Secretary shall promulgate regulations limiting the quantity therein or thereon to such extent as he finds necessary for the protection of public health, and any quantity exceeding the limits so fixed shall also be deemed to be unsafe for purposes of the application of clause (2) of section 402(a). While such a regulation is in effect limiting the quantity of any such substance in the case of any food, such food shall not, by reason of bearing or containing any added amount of such substance, be considered to be adulterated within the meaning of clause (1) of section 402(a). In determining the quantity of such added substance to be tolerated in or on different articles of food the Secretary shall take into account the extent to which the use of such substance is required or cannot be avoided in the production of each such article, and the other ways in which the consumer may be affected by the same or other poisonous or deleterious substances."

Considering both sections of the Act, it would appear that the Food and Drug Administration has ample authority to protect the public from dangerous pesticide residues on foods. If the Administrator finds that a poisonous or deleterious substance is required in the production of a food or that it cannot be avoided by good manufacturing practices, he is obliged to promulgate regulations limiting the quantity therein or thereon—in other words, establish a tolerance. On the other hand, if he finds such a substance is not necessary in production or could be eliminated, proceedings can be instituted under Section 402.

Unfortunately, the Food and Drug Administration, in the 13 years the statute above has been in effect, has seen fit to promulgate tolerance regulations in only one instance. In 1944 tolerances for fluorine on apples and pears were established

by a regulation. Even these tolerances were subsequently invalidated by court action, so that at the present time there are no official tolerances on the books. However, as you are all aware, somewhat over a year ago the Food and Drug Administration held lengthy hearings for the purpose of taking evidence upon which to establish tolerances for all of the pesticidal materials which the Administrator may consider necessary for use in the production of fresh fruits and vegetables. These hearings were concluded over a year ago, but to date the proposed tolerances have not been released.

In addition to the two federal statutes, at least 39 states have legislation regulating the movement and use of pesticides, and many states have provisions governing pesticide residues on or in foods in their Food and Drug or Public Health laws.

Following the passage of the Federal Insecticide, Fungicide, and Rodenticide Act of 1947, which in my opinion has done more than any other single piece of legislation effectively to control and regulate the use of pesticides, things seemed to move smoothly for a few years. Occasionally instances of alleged or actual contamination of foods by toxic substances arose, but in most cases the reports were in error or the incident was attributable to accidental contamination or to carelessness and ignorance. Such incidents, of course, cannot be entirely eliminated through legislation but could be more properly approached through educational processes.

Recently, however, as food processing and handling have become more highly industrialized, more and more chemicals have found their way into or have come into contact with foods. Many chemicals are now intentionally added directly to foods to impart to them some essential or at least desirable characteristic, such as flavor, texture, appearance, nutritional value, keeping quality, etc. Simultaneously, science has placed in the hands of the entomologist, the plant pathologist, and the farmer many new chemicals possessing heretofore practically unknown pesticidal values, many of which have come into common, though frequently restricted, use.

The over-all increase in the use of chemical additives in the production and processing of foods caused some competent scientists to express concern with regard to the effect this increased use of chemicals might have on public health. A number of crackpots, publicity seekers, and misguided individuals immediately seized upon the idea and the country was flooded with an almost endless series of scare stories. As the public began to show some degree of concern, the witch hunt got underway in earnest. Just as clever manipulators in colonial days played upon the psychological responses of man to explain all unexplainable events and circumstances by attributing them to evil spirits, sorcerers, and witches, so, too, the manipulators and ill-advised philosophers of our day have through speculation and implication attempted to explain the ills of today by attributing them to the possible presence of chemicals in foods. In recognition of the rising feeling of apprehension, on June 20, 1950, Congress approved House Resolution 323 authorizing the appointment of a select committee to be composed of seven members of the House of Representatives. This committee, frequently referred to as the Delaney Committee, was authorized to:

". . . conduct a full and complete investigation and study of—(1) the nature, extent, and effect of the use of chemicals, compounds, and synthetics in the production, processing, preparation, and packaging of food products to determine the effect of the use of such chemicals, compounds, and synthetics (A) upon the health and welfare of the Nation and (B) upon the stability and well-being of our agricultural economy; (2) the nature, extent, and effect of the use of pesticides and insecticides with respect to food and food products, particularly the effect of such use of pesticides and insecticides upon the health and welfare of the consumer by reason of toxic residues remaining on such food and food products as a result of such use . . . "

The resolution further states that:

" . . . the committee shall report to the House . . . the results of its investigation and study, together with such recommendations for legislation as it may deem advisable."

This committee held public hearings extending over a period of several weeks and in late December prepared a rather voluminous report of its findings. The committee requested that it be continued by the new Congress and when this request was granted, the public hearings were resumed on April 12 and presumably are still in progress. Just when the hearings will be terminated and what the

recommendations of the committee will be must, of course, remain a matter of conjecture until such time as the committee files its final report with Congress.

Since, according to the wording of House Resolution 323, the committee is obligated to consider the stability and well-being of our agricultural economy as well as the public health problems associated with chemical usage, it would appear to be expedient that the question of pesticides which are essential to the success of agriculture should be considered as a problem separate and distinct from the intentional additives placed directly in foods. The separation of these two quite distinct problems is further justified by the fact that pesticides are covered by the Federal Insecticide, Fungicide, and Rodenticide Act, whereas the intentional additives are not. The testimony of many witnesses would appear to reflect a belief that the use of pesticides is optional and could be eliminated. Apparently many witnesses failed to realize that fruits and vegetables, so essential to the maintenance of a well-balanced diet, could not be produced without the use of pesticides, and they showed no inclination to accompany their picture of the horrors inherent in pesticide residues with an equally vivid picture of the dire effects of malnutrition that would inevitably follow the elimination of pesticides.

In so far as pesticides are concerned, it would appear that the primary issue before the committee relates to the adequacy of existing federal laws to protect the public health from injury resulting from residues of pesticides used in the production of food crops. If the committee finds that present legislation is adequate, we will no doubt continue to operate under the existing laws. If, on the other hand, the committee deems present legislation to be inadequate, new legislation will no doubt be recommended.

The text of the interim report, the tactics followed by the committee's chief counsel, and Mr. Delaney's article in the July issue of the *American* magazine all tend to lead one to believe at least some legislative proposals will be made. On November 28, 1950, a representative of the Food and Drug Administration, appearing before the committee, took the position that present laws are inadequate to provide the consumer an adequate degree of protection and proposed several amendments to the present Food and Drug Act. Congressman Miller of Nebraska, a member of the committee, incorporated these suggestions into a Bill, H. R. 3257 (82nd Congress, 1st Session), which he introduced in the House of Representatives on March 15, 1951. This Bill defines the term "chemical additive" as any substance intended to be used in a manner that is likely to result in contamination of food.

> " . . . which substance is not generally recognized, among experts qualified by scientific training and experience to evaluate the toxicity of such substances, as having been adequately tested to show that it is not poisonous or deleterious, or if it is poisonous or deleterious and is intended for use where a poisonous or deleterious substance is required in the production of food, that it is not so recognized by such experts as having been adequately tested to show that it is safe for such use."

Section 408 provides:

> "(a) No person shall introduce or deliver for introduction into interstate commerce any chemical additive as defined in section 201(q) unless an application filed by such person pursuant to subsection (b) is effective with respect to such chemical additive."

The item (b) referred to above and subsequent provisions may be summarized as connotating express or implied permission of the administrator.

It seems to me that if enacted into law this bill would in a large measure duplicate, if not indeed supersede, the Federal Insecticide, Fungicide, and Rodenticide Act, and would in effect place in the hands of one man, or at most a few men, in the Food and Drug Administration dictatorial powers rivaling those held by Hitler and Stalin. You should bear in mind that in an attempt to obtain the passage of this or any similar bill, men in high places may attempt to explain it as a simple, harmless safeguard of the public welfare, but you must be prepared to face the various interpretive regulations that would follow its enactment into law. Even though representatives of the Food and Drug Administration proposed this legislation, once the bill is enacted into law, if history repeats itself, you may be told by these same individuals or their successors, "We are not responsible for the provisions of this act—we have a mandate from Congress, and we cannot take any chances on endangering the public health." With this alibi they could,

and no doubt would, resort to innumerable arbitrary and dictatorial actions.

The controversial issues involved in the Delaney Committee hearings and the legislative proposals which may evolve from it are of vital importance to everyone interested in pest control in any way whatsoever. The proceedings of the Delaney Committee hearings, the existing federal statutes, proposed new legislation, and representative editorial comments thereon should be required reading for every scientist interested in pest control problems. The day may not be far distant when you will be called upon to present your knowledge of the facts clearly to your representatives in Congress.

It is true that from time to time minor regrettable incidents occur, but to date almost without exception they have been attributable to ignorance, indifference, or carelessness. I submit to you that these three factors cannot be rectified by legislation. Education—and education alone—can bring about the solution of such problems. The American Medical Association, through its Committee on Pesticides, and the National Research Council, through its Food Protection Committee, are attempting to expedite the educational program by screening and summarizing available research data so that it may become more readily available to educational groups and the public in general. Individually and collectively we should, through our respective associations, do everything within our power to develop and promote an adequate over-all educational program.

Many people believe that existing legislation is adequate, particularly *if* it were fully utilized by the agencies which have the responsiblity for its administration. This being true, it would be optimistic indeed to hope that new legislation could improve on the potentialities of existing laws. Developments of the past several months have given rise to speculation that some agencies may wish to divert attention from their failure to administer existing laws by creating a smokescreen of alleged need for new legislation.

From the standpoint of its nutritional requirements and its agricultural economy, our nation cannot afford to indulge in a witch hunt to placate the fears of those people unduly excited by a wave of prejudiced and inaccurate publicity. Vigorous and unrelenting insistence on impartial consideration of all the issues involved is the best and perhaps the only means of insuring legislation which will best serve the needs of the nation as a whole.

GEORGE C. DECKER, *Illinois State Natural History Survey, Urbana*

BOOK NOTICE

ELEMENTS OF PLANT PROTECTION by Louis L. Pyenson. With Line Drawings by Emily B. Steffens. John Wiley & Sons, Inc., New York. 1951. $8\times5\frac{3}{8}''\times\times+538$ pp. 226 figures. $4.96.

This volume by Dr. Pyenson, who is the entomologist and plant pathologist of the Long Island Agricultural and Technical Institute is the result of his experience in 12 years of teaching courses in plant protection to agricultural and horticultural students. As a text and source book for agricultural students, and as a comprehensive outline for instructors who teach the elements of plant protection, this volume appears to meet all the requirements for a broad understanding of the entire subject. Its 28 chapters cover the development of insects, life history, classification, invertebrates other than insects, control of insects and other invertebrates, chemical control of insects, mammals and birds harmful to agriculture and their control, plant diseases their causes and life history, plant disease control, weeds and their reproduction and control, spraying, dusting and herbicide application equipment and its selection and care. These subjects are followed by a list of reference books, a glossary and an index. At the end of each chapter there is a list of discussion questions.

The book is a carefully planned, organized, and well thought out, clear presentation, of elementary information, on all plant pests, that has been tested in the classroom. It is intended, of course that its use as a text should be supplemented by laboratory work. However the text itself is extremely useful as a reference book. Dr. Pyenson has brought together an extensive array of information on all aspects of plant protection which is presented in a straightforward, concise and detailed manner. It should be welcomed by teachers.—H.B.W.

PROCEEDINGS OF THE SIXTY-THIRD ANNUAL MEETING

AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS
Netherland Plaza Hotel, Cincinnati, Ohio
December 10, 11, 12, 13, 1951

The sixty-third annual meeting of this Association was held at the Netherland Plaza Hotel, Cincinnati, Ohio, December 10 to 13. In conjunction therewith the American Phytopathological Society and the Potato Association of America held their annual meetings. As has been the practice for several years, the Entomological Society of America met with this Association, in several joint sessions. The program for the meetings were worked out by a committee consisting of A. G. Johnson, C. E. Mickel, L. D. Christenson, Chairman of this Association and C. E. Kennedy, M. D. Leonard and C. F. W. Muesebeck, Chairman for the Entomological Society of America. After the preliminary work was done L. D. Christenson was transferred to Hawaii and Howard Baker served as acting chairman. It is a pleasure to record the efficient way in which he took hold of the outline and completed the program.

While the main portion of the program started on Monday the Executive Committee met on Saturday night and most of Sunday. A conference of research workers on the corn earworm under the leadership of L. P. Ditman was scheduled for Sunday night. It was attended by about 10 research men and approximately 40 interested auditors.

The registration was over 600 for both societies of entomologists; over 500 phytopathologists and several hundred members of the Potato Association made a record breaking total registration of about 1200 for this joint endeavor. There were many joint meetings, several symposia and an interesting showing of moving pictures.

Arrangements in the hotel were excellent and the management should be commended for their interest and helpful attention to the details that insured the success of this large meeting of scientists. The local committee on arrangements of which C. R. Cutright was designated chairman did a splendid job. The actual work fell to the lot of T. H. Parks as acting chairman because Cutright found after his appointment that he would be out of the country at the time of the meetings. Parks was assisted by Miss Annette Braun, W. A. Price, R. H. Davidson, M. W. Boesel, J. N. Knull and D. M. DeLong.

The list of appointments made by President Campbell throughout the year is on page 148:

REPORT OF THE SECRETARY

Through careful planning and the cooperation of the editor, the Publications Committee, the George Banta Publishing Company and the Business Management, a schedule of production items has been set up that has resulted in the mailing of most of the current issues during the month designated on the cover. We are able now to set deadlines for most activities. A major source of irritation to members is thus allayed. It has been difficult however to keep all the addressograph listing up to date. Therefore, there have been some complaints of non-receipt of the Journal. Actually, entomologists seem to move more than most other professionals; maybe that is progress or possibly fuguism.

The *Index VIII* is now being distributed to those members who were thrifty enough to take advantage of the pre-publication price. The Executive Committee has authorized a special sale for one month through January, at a price of $4.00 to members. Thereafter, the price will be $7.00 to non-members and $5.25 to members.

The cost of *Index VIII* was $5537.14 to which will be added the bill for postage. The volume contains 805 pages. The Association is greatly indebted to Dr. Ralph Shaw, Librarian of the U.S.D.A. Library for the typing of the material in such form that it could be photoprinted, to the Division of Insects for checking the scientific names, and to Miss Ina Hawes as Editor. Although the Secretary was authorized to borrow money from the Permanent Fund, the financing of *Index VIII* so far has been done entirely through current funds.

Entoma, under the capable leadership of G. S. Langford, Editor, is in process of being printed and will be available for distribution in a short time. This publication is gaining recognition on a world-wide basis and serves a most useful purpose.

Costs of publications have risen sharply; as an example, the April 1948 issue of 196 pages cost $2529.43. For 208 pages in the October issue of 1951 the cost was $4016.15. The cost for the last 16-page signature was $144.57, so that the cost for 192 pages in October 1951 was $1342.15 higher than 196 pages in 1948 or about 53 per cent increase.

It becomes imperative if we are to continue as a going solvent concern to increase dues and nonmember subscription rates. There seems to be a tendency in some organizations to look to the National Science Foundation or other agencies for help in publication but it is my sincere belief that the integrity of our scientific work can only be assured by independence maintained at some individual financial sacrifice.

The secretaries of several branches are doing an outstanding service to the Association in distributing application blanks within their territories. Heads of departments have been furnished blanks and they also have been most helpful in bringing the desirability of membership to the attention of prospective members. A new method of passing on members is imperative. If no change is made in the requirements for memberships the Association can easily expand to 4,000 or more with the continued and expanded efforts of Branch Secretaries, heads of departments and individuals.

The membership distribution by Branches at present is as follows: Eastern 717, North Central 435, Cotton States 399, Southwest 248 and the Pacific Branch 639.

There have been admitted 323 new members during the year; these will be listed by the Membership Committee and their names included in the list that will be published in February. The total membership stands at 2950. The deaths, resignations and new members will be presented by the Membership Committee. The subscription list amounts to approximately 4800. The Journal goes to 88 foreign countries.

Letter ballots were sent out in regard to consoli-

dation, election of the President and First Vice President and a run-off ballot for First Vice President. These last ballots were put on post cards with the hope that a better total vote would be registered. Only 1288 votes were cast in the first ballot; in the run-off only 1442 post cards were returned. Thus only about 50 per cent vote which is comparable, with the indifference on national, state and county voting on the election of public officers.

Dr. E. F. Knipling was elected President and Dr. H. G. Johnston First Vice President. Consolidation was approved 1224 to 217 by this Association but was lost in the Entomological Society of America by 1.6 per cent.

In the February Journal 1936, Bourne reported that at Pittsburgh in 1934, the membership was 1159; at St. Louis in 1935 he reported 1150 of which 718 were active members and 54 foreign members. The increase since that time has been approximately 156 per cent.

AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

AUDIT REPORT

For the fiscal year ended November 30, 1951

December 6, 1951

Mr. Roy E. Campbell, President,
American Association of Economic Entomologists,
Box 70,
Whittier, California

Dear Mr. Campbell:

In accordance with the recent request of Dr. Ernest N. Cory, I have examined the accounting records of the Secretary-Treasurer of the American Association of Economic Entomologists for the fiscal year ended November 30, 1951, and present herewith statements of receipts and disbursements of the General Fund, Permanent Fund and Special Journal Fund for the year, which were prepared from the records.

The examination included such tests and checks as were deemed necessary and adequate in the circumstances. However, a detailed audit was not made.

In my opinion, the accompanying statements accurately reflect the recorded cash receipts and the authorized disbursements made for the benefit of the Association during the period. The balances of cash and securities at the beginning and at the end of the period were verified by me by actual count or were confirmed directly by the banks.

Very truly yours,
JOHN A. HERL

AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

GENERAL FUND

Statement of Receipts and Disbursement
For the fiscal year ended November 30, 1951

	Total	*Journal*	*Association*	*Indices*	*Entoma*
Receipts:					
Subscriptions	$17,166.75	$ 17,166.75			
Advertising	1,837.12	1,837.12			
Reprints	2,514.59	2,514.59			
Back Numbers and Miscellaneous	1,323.22	1,323.22			
Membership Dues	6,914.50		$ 5,762.08	$1,152.42	
Sale of Indices	1,588.60			1,588.60	
Interest on Bonds	50.00		50.00		
Cash Overage	9.50		9.50		
Federal Income Tax—withheld but not yet paid	74.70		74.70		
Total Receipts	$31,478.98	$ 22,841.68	$ 5,896.28	$2,741.02	$ —0—
Disbursements:					
Journal Costs—Printing and Mailing	$25,215.69	$ 25,215.69			
Engravings	981.18	981.18			
Costs of Editing Index VIII	5,537.14			$5,537.14	
Salaries and Wages—Stenographic and Clerical	3,780.87	1,682.43	$ 1,682.44		$ 416.00
Honorarium—Editor	600.00	600.00			
Honorarium—Business Manager and Secretary-Treasurer	600.00	300.00	300.00		
Postage, Stationary and Office Supplies	2,209.92	855.06	855.06		499.80
Travel Expense	1,200.80		1,200.80		
Accounting Service	100.00	50.00	50.00		
Telephone and Telegraph	19.96		19.96		
Fidelity Bond	12.50	6.25	6.25		
Rental—Safe Deposit Box	7.20		7.20		
Refunds—Subscriptions and Back Numbers	82.65	82.65			
Advertising Commissions	22.50	22.50			
Meeting Expenses	483.87		483.87		
Collection and Bank Charges	4.09	2.05	2.04		
Federal Income Tax—withheld 1950 paid in 1951	95.45		95.45		
Total Disbursements	$40,953.82	$ 29,797.81	$ 4,703.07	$5,537.14	$ 915.80
Excess of Disbursements over Receipts	$ 9,474.84	$ 6,956.13	$—1,193.21	$2,796.12	$ 915.80
Balance, December 1, 1950	18,326.83	2,391.51	8,882.53	7,052.79	—0—
Balance, November 30, 1951	$ 8,851.99	$—4,564.62	$ 10,075.74	$4,256.67	$—915.80

RECAPITULATION

Suburban Trust Company—Checking Account	$ 6,851.99
U. S. Savings Bonds, Series G, 2½%—Cost	2,000.00
Total Cast and Securities	$ 8,851.99

AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

PERMANENT FUND

Statement of Receipts and Disbursement
For the fiscal year ended November 30, 1951

Balance, December 1, 1950		$18,220.78
Receipts:		
Interest on Bonds	$ 361.25	
Interest on Savings Deposit	12.83	
Increment to redemption value of U. S. Savings Bonds, Series F	58.50	
Life Membership	50.00	
Total Receipts		482.58
Fund Balance after Receipts		18,703.36
Disbursements:		
None		—0—
Balance, November 30, 1951		$18,703.36

RECAPITULATION

Securities

Face Value		*Book Value*	
$ 2,000.00	Province of Ontario 5% Debenture Bonds of 1959, at Cost	$2,000.00	
3,000.00	U. S. Treasury 2¼% Bonds, 1955–60 at Cost	2,984.00	
7,000.00	U. S. Savings Bonds, Series G, 2½% at Cost	7,000.00	
6,500.00	U. S. Savings Bonds, Series F, at Current Redemption Value	4,901.00	
$18,500.00	Total Securities		$16,885.00

Cash

Suburban Trust Company—Savings Account	695.86	
Suburban Trust Company—Checking Account	50.00	
First Federal Savings & Loan Association	1,010.00	
Cash on Hand	62.50	
Total Cash		1,818.36
Total Securities and Cash		$18,703.36

AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

SPECIAL JOURNAL FUND

Statement of Receipts and Disbursement
For the fiscal year ended November 30, 1951

Balance, December 1, 1950	$527.60
Receipts:	
Interest on Savings Deposit	5.00
Fund Balance after Receipts	532.60
Disbursements:	
None	—0—
Balance, November 30, 1951	$532.60

RECAPITULATION

Suburban Trust Company—Savings Account	$532.60

REPORT OF COMMITTEES

Report of Nominating Committee

The results of the mail ballot for President and Vice President of the American Association of Economic Entomoligists, which have been announced previously, are as follows:

President, EDWARD F. KNIPLING
First Vice President, H. G. JOHNSTON

Your committee submits the following nominations for your consideration:

Pacific Slope Branch, GLEN E. CARMAN
Cotton States Branch, CHARLES H. ALDEN
Eastern Branch, FLOYD F. SMITH
North Central States Branch, ROGER C. SMITH
Southwestern Branch, R. C. BUSHLAND
Section of Apiculture, W. A. PRICE
Section of Plant Pest Control and Quarantine, H. S. DEAN
Section of Extension, J. O. ROWELL
Section of Teaching, A. C. HODSON
Section of Insecticides,
Section of Medical Entomology, A. W. A. BROWN
Section of Biological Control, ALVAH PETERSON

Executive Committee:
H. M. ARMITAGE
W. DOYLE REED

Committee on Membership:
H. O. LUND
L. C. MURPHREE

Committee on Common Names of Insects:
A. B. GURNEY, *Chairman*
T. R. ROBB
C. E. SMITH (La.)
ELMOE D. HARDY
A. E. MICKELBACHER

Program Committee:
HOWARD BAKER, *Chairman*

Committee on Insecticide Terminology
MILLARD SWINGLE

Trustee for Permanent Fund
CLAY LYLE

Councilor for A.A.A.S.
CLYDE F. SMITH

Representative to the National Research Council:
FLOYD F. SMITH

Committee on Nominations
H. H. SHEPARD
OLIVER I. SNAPP
K. P. EWING
ED. H. LITTOY
W. E. DOVE Chm.

Journal of Economic Entomology

Editor;
L. M. PEAIRS

Associate Editor:
H. B. WEISS

Publications Committee:
C. H. MARTIN, *Chairman*
Edward A. STEINHAUS
H. L. SWEETMAN

Special Committee on Constitutional Changes
B. A. Porter, *Chairman*
C. F. W. Muesebeck, *Vice-Chairman*
J. L. Horsfall
Harlow Mills
H. M. Harris

Special Committee on Welfare of Entomology as Affected by Hoover Committee Report
Clay Lyle, *Chairman*
George C. Decker
T. L. Aamodt
C. E. Palm
L. S. Hitchner

Committee on Illustrative Material
M. P. Jones, *Chairman* (Reappointed)
Chas. E. Palm
J. L. Horsfall

Joint Committee for Development of Entomological Taxonomy

For the A.A.E.E.	For the E.S.A.
J. L. Horsfall, *Chairman*	Roger B. Friend
C. F. W. Muesebeck	Marston Bates
Harlow Mills	LaVerne L. Pechuman

Committee on Insect Pest Survey
George C. Decker, *Chairman*
T. L. Aamodt
W. C. Nettles
H. M. Armitage
Kelvin Dorward

APPOINTMENTS, 1951

Delegate to 14th International Beekeeping Congress, at Leamington Spa, England, Sept. 3–8, 1951.
H. F. Menke

Official delegation to 9th International Congress of Entomologists at Amsterdam, August 17–24, 1951
Albert Hartzell, Head of Delegation
V. C. Dethier
F. C. Bishop
S. S. Easter,
G. L. Hutton
Lt. Col. R. W. Bunn
Geo. N. Wolcott

Liaison Representative—Food Production Committee of National Research Council
E. F. Knipling

Representative on Joint Committee on Grassland Farming
W. A. Baker

Entomological Representatives at the 3rd Nat. Conference of U. S. National Commission for UNESCO, January 27–31, 1952, New York, N. Y.
S. B. Fracker
Geo G. Becker

Official Representative at the 1st Meeting of the Entomological Soc. of Canada, Ottowa, Nov. 1–3, 1951
C. E. Palm

Joint Local Arrangements Committee for Cincinnati Meeting
Chairman,
C. R. Cutright
Acting Chairman
T. H. Parks
Annette Braun
W. A. Price
R. H. Davidson
M. W. Boesal
J. N. Knull
D. M. DeLong

Representative at the Inauguration of President Hatcher of the University of Michigan

S. A. Graham

Representative at the Inauguration of new President at the University of Arizona

J. N. Roney

Nominating Committee of Association

W. E. Dove, *Chairman* K. P. Ewing
Harold H. Shepard E. H. Littoy
Oliver I. Snapp

REPORT OF COMMITTEE ON COMMON NAMES OF INSECTS

A total of 47 proposed new names and 11 suggested changes in names previously approved were assembled in ballot form and circularized to members of the Committee on Common Names of Insects for consideration late in the year. The final decision of the Committee with respect to these proposals is not yet available.

To assure that the affairs of this important Standing Committee will be in position to receive adequate and appropriate attention each year, the Committee respectfully offers for consideration the following suggestions:

1. That in selecting members of the Committee on Common Names of Insects the Nominating Committee continue to give careful consideration to persons known to have an interest in the subject.

2. That in selecting members of this Committee an effort be made to assure that as many geographical areas as possible will be represented.

3. That an attempt be made to include on this Committee representatives of the various subject-matter fields of Entomology, such as taxonomy, research, teaching, extension, and regulatory.

4. That the individual nominated as Chairman of this Committee have a background in insect taxonomy; that he be consulted by the Nominating Committee prior to placing his name in nomination as Chairman in order to make certain he will be in position to devote the necessary time and attention to the affairs of the Committee; and that it be the general policy to have the Chairman serve for a period of at least two or preferably three consecutive years.

The Committee.

A. B. GURNEY
P. O. RITCHER
DONALD MACCREARY
ROBERT GLEN
F. E. WHITEHEAD
A. N. TISSOT
T. A. BRINDLEY
T. L. AAMODT
G. J. HAEUSSLER, *Chairman*

REPORT OF THE COMMITTEE ON MEMBERSHIP

The following deaths have occurred among the membership: S. E. Crumb, Jr., H. L. Dozier, former member who has two sons who are entomologists, H. E. Ewing, Clifton B. Hitt, Neale F. Howard, Dudley Moulton, Harold I. O'Byrne, E. F. Phillips (past President), H. J. Quayle, S. A. Rohwer (past President), W. A. Thomas and W. H. White.

Nineteen (19) members have resigned during the year, four (4) on account of retirement.

New members admitted during the year before your secretary left his office total 231. Ninety-two (92) have been placed on the rolls as of January 1, 1952 and 23 applications have been received at this meeting making a total of 346.

The membership is distributed by Branches as follows: Eastern 717, Cotton States 399, North Central States 435, Southwestern 248 and the Pacific Branch 639.

Membership is increasing marvelously. Since 1936 when the present secretary took office there has been an increase of more than 156 per cent in members.

Every man earning his living in entomology should be a member of this organization. President Campbell has told you why in his address. Today there are many entomologists working for federal and state agencies that do not belong. As a matter of self interest they should belong and employers of entomologists should urge their participation in the organization that represents so ably their life work. Without your Association there would be no JOURNAL OF ECONOMIC ENTOMOLOGY to keep you informed of the latest results of your co-workers' research. Each entomologist, besides belonging, should urge every other entomologist to join and then this Association would not stop at 2959 members but will exceed 4000 in a very short time.

COMMITTEE ON INSECT PEST SURVEYS

The temporary committee on Insect Pest Surveys appointed by President Roy Campbell under date of November 11, 1951 has duly considered the three questions presented to it and desires to report as follows:

I. Your committee unanimously agreed that there is an immediate pressive need for the services of an association committee on Insect Pest Surveys and that this need may be permanent or transitory. We are hesitant to recommend the appointment of a standing committee at this time. We do, however, recommend that a committee of six (6) be appointed to serve for a period of three (3) years and that at the end of this period the committee shall make recommendations for its abolition, continuation or change to standing committee status. Said committee to include representation from the Bureau of Entomology and Plant Quarantine, Extension Service, State Agricultural Experiment Stations, State Regulatory groups and from Industry. The individual in charge of surveys in the B.E.P.Q. will be an *ex officio* member.

II. The committee recommends that, for the time being, the Association shall proceed "on its own" in this matter and not consider joint action with the Entomological Society of America.

III. The committee members unanimously agreed that a strong active Insect Pest Survey Committee could serve a very useful purpose in supplying assistance, direction and advice, either voluntarily or upon request, to the Chief of the Bureau of Entomology and Plant Quarantine and representatives of other agencies interested in Survey work.

It could also serve as an appropriate liaison contact for agencies such as the American Phytopathological Society, Entomological Society of America, Federal Civil Defense Administration or others seeking cooperation with our Association.

Respectfully submitted for the Committee

G. C. DECKER, *Chairman*

REPORT OF COMMITTEE ON ILLUSTRATIVE MATERIAL

At the last annual meeting of the Association your committee made reference to the possible development of a code of terms used by entomologists. This comment was favorably received and so stated by many members of the Association. Your committee had for several years been observing the terms used and had already begun to develop a code at the time of the Denver Meeting in 1950. The practice has been continued. Early in September of this year a list of the terms and code assembled was duplicated and distributed to the entire membership by the secretary of the Association. The letter of transmittal invited suggestions and constructive criticisms.

Your committee wishes to express appreciation for the many letters received giving additional terms with code, and for the wholehearted approval by most of those who replied. The comments received from the members showed that careful study of the suggested list had been made. The list has been expanded to include the additional terms and code that reached your committee in time to be included in this report. In cases of alternate suggested codes, the ones endorsed by the greatest number were accepted except that every effort was made to adopt the code for a term that was already in common use or had been adopted by some group. However, for the sake of brevity it was necessary to shorten some codes that were in common use. It is recognized that some of the code listed below will seldom be used but because the segment of our membership to which these codes apply was kind enough to submit them they were included so that they might be considered with the others.

The list appears long and may be difficult to memorize but it should be observed that many of the terms and code are already in use and some of them will seldom be used. Therefore, it should not be too difficult to familiarize one's self with the remainder of the code if everyone making slides and charts will make full use of them. It is well to use the full term when it does not occupy too much space on the slide or chart but it should be remembered that an overloaded slide is worthless. Clear, concise slides with standard code are all the more necessary to assist the many people to interpret the photographs made of projected slides; also, to interpret charts and graphs used in the various publications. If adopted the code will always be available to the makers of slides, charts, and graphs and to the person reading publications using this illustrated material. The speaker using the slide can state the term as he refers to the code and that will help the membership to familiarize themselves with the code. It is encouraging to note that some members are already using the suggested code as mailed to them.

1. The response to the code has been so gratifying that your committee recommends the acceptance of the following listed code as a standard form and that if accepted it be published in the Journal with this report.

2. Your committee recommends that some continuing committee, possibly the one on insecticide terminology, be given the responsibility of adding to the present list as necessity warrants.

3. As the committee has completed its assignment and as there is a desire to hold the number of committees in the Association to the minimum, it is recommended that this Committee on Illustrative Material be discharged

Therefore, we move that the report be accepted. Carried.

Respectfully submitted,
CHAS F. PALM
J. L. HORSFALL
M. P. JONES, *Chairman*

CODE OF TERMS FOR USE OF ENTOMOLOGISTS IN MAKING SLIDES, CHARTS, GRAPHS, LABELS, ETC.

Ins	*Ins*ecticides
Ald	*Ald*rin
Ale	*Alle*thrin
BHC	*B*enzene *H*exachloride
CaA	*Ca*lcium *A*rsenate
Chd	*Chl*or*d*ane
Cry	*Cry*olite
DDT	*D*ichloro *D*iphenyl *T*richlorothane
DD	*D*ichloropropylene and *d*ichloropropane
Dld	*Diel*drin
Dil	*Dil*an
DMDT	Methoxychlor (*dim*ethoxy *d*iphenyl *tri*chloroethane)
DNOC	*Di*nitro *o*rthocresol
DNOP	*Di*nitro *o*rthocyclohexyl *p*henol
DN	Various *di*nitro compounds
EDB	*E*thylene *di*bromide
EDC	*E*thylene *di*chloride
EON	EPN 300
GBH	*G*amma *b*enzene *h*exachloride
Hpch	*Hep*tach*l*or
NicB	*Nic*otine *b*entonite
NicS	*Nic*otine *s*ulfate
OE	*O*il *E*mulsion
PDB	*Para*di*chloro*benzene
Para	*Para*thion
PcP	*P*entachloro*p*henol
Pyr	*Pyr*ethrum
P.B.	*P*iperonyl *b*utoxide
Rtn	*Rotenone*
S	Sulfur
Sab	*Sab*adilla
Scn	*Scabrin*
SPP	*S*odium *p*entachloro*p*henote
SO	*S*ummer *O*il
SpO	*Sup*erior *o*il
TDE	*T*etrachloro *b*iphenyl *e*thane
TEPP	*Tet*ra*e*thyl *p*yrophos*p*hate
Tha	*Tha*nite
Tox	*Tox*aphene
FOI	*F*orm *o*f *I*nsecticides
Acd	*Acid*
Aes	*Aero*sol
Alk	*Alk*ali
Ba	*Ba*sic
Conc	*Conc*entrate
Emu	*Emu*lsion
Inorg	*Inorg*anic
Neu	*Neu*tral
Org	*Org*anic
Pwd	*Pow*der
Sp	*Sp*ray
WP	*W*ettable *p*owder
MAP	*M*ethod of *ap*plication
AD	*A*eroplane *d*uster
ASp	*A*eroplane *Sp*rayer
CD	*C*rank *d*uster
CSp	*C*ompressed air *sp*rayer (3 gallon type)
Dst	*Dus*ted
D	*D*uster
Fum	*Fum*igant

HD	*H*and *d*uster (plunger type)
HPAes	*H*igh *p*ressure *a*erosols
HSp	*H*and *s*prayer (plunger type)
KBD	*K*napsack *b*ellows *d*uster
KSp	*K*napsack *s*prayer (continuous pumping type)
LPAes	*L*ow *p*ressure *a*erosols
MSp	*M*ist *s*prayer
PoD	*P*ower *d*uster
SSp	*S*peed *s*prayer
Spd	*S*prayed
UOM	*U*nits of *m*easure
A	*A*cre
Bu	*Bu*shel
Bu/A	*Bu*shels *p*er *a*cre
C/M	*C*ounts *p*er *m*inute
CuFt	*Cu*bic *f*oot
Dd	*D*ead
°C	*D*egrees *c*entigrade
°F	*D*egrees *f*ahrenheit
Ft	*F*oot
Gl	*G*allons
Gl/A	*G*allons *p*er *a*cre
Gl/MB	*G*allons *p*er *1000 b*ushels
Gl/MFt	*G*allons *p*er *1000* square *f*eet
Gr	*G*ram
LD50	*D*ose *l*ethal to *50* per cent of individuals
Mcg/Cm²	*M*icrograms *p*er *s*quare *c*entimeter
MLD	*M*edian *l*ethal *d*ose
N	*N*umber
N/L	*N*umber *p*er *l*eaf
Oz	*O*unce
PPM	*P*arts *p*er million
/	Per
/Sd	*P*er *s*eed
/In²	*P*er *s*quare *i*nch
%	*P*er *c*ent
% Ct	*P*er *c*ent *c*ontrol (comparison of check with treated)
% Dd	*P*er *c*ent *d*ead
% Rd	*P*er *c*ent *r*eduction (comparison before and after treatment)
% M	*P*er *c*ent *m*oribund
Pt	*P*int
Pt/A	*P*ints *p*er *a*cre
P	*P*ounds
P/A	*P*ounds *p*er *A*cre
Pt/100 g	*P*ints *p*er *h*undred *g*allon
P/100g	*P*ounds *p*er *h*undred *g*allons
PSI	*P*ounds *p*er *s*quare *i*nch
PT/A	*P*ounds *t*echnical material per *a*cre
Swp	*S*weep
Sw	*S*wath
X	Time normal concentration
WS	*W*ing *s*pread
Yld	*Y*ield
Misc	Miscellaneous
AA	*A*ctual *a*pplication (actually applied)
AI	*A*ctive *i*ngredient
Act	*A*ctual
Av	*A*verage
Calc	*C*alculated
Ck	*C*heck
Ctg	*C*oating
Dep	*D*eposit
Dlu	*D*iluent
Dln	*D*ilution
DrpSz	*D*roplet *s*ize
Emg	*E*mergence
Estd	*E*stimated
FO	*F*ungicide *o*nly
Grm	*G*ermination
IO	*I*nsecticide *o*nly
KD	*K*nock *d*own
LSD	Least significant difference
LS	*L*atin *s*quare
PG	*P*eet *g*rady
RB	*R*andom *b*lock
Rnd	*Rand*omized
RA	*R*ate of *A*pplication
Rpl	*Rep*lication
Slv	*Solv*ent
Std	*St*andard treatment for comparisons
Syn	*Syn*ergist
Txn	*Tox*icant
Txc	*Tox*icity
Trm	*Treatm*ent

REPORT ON INDICES TO THE LITERATURE OF AMERICAN ECONOMIC ENTOMOLOGY

We were appointed by Dr. Boyce, February 14, 1949, to supervise the preparation of Index VIII to the Literature of American Economic Entomology. Since that volume has now been published the committee has presumably passed out of existence. Nevertheless, it seems to us that we should (whether as a committee or simply as three members of this Association is unimportant) advise the Executive Committee of a rather critical situation that exists with respect to the preparation of future volumes in this series.

The Library of the Department of Agriculture which has provided the technical and clerical personnel for the actual preparation of the Indexes, has been forced to revise many of its projects and to redistribute work loads owing to reductions in personnel and operating funds. In these adjustments the best the Library can do is to leave only one employee on this project. Up to the present two persons have been giving full time to it.

Even under the conditions existing up to the present it has been difficult, at times impossible, to keep up to date; and once the indexing has fallen behind it has not been possible to recover the lost ground while indexing the current literature. This is indicated in the following summary of the status of the Indexes as of November 1951:

Index VIII (1945–1947)

Sent to the printer on July 19, 1951. Now published.

Index IX (1948–1949)

Omitted in the series. A large backlog of indexing accumulated during the time spent in revising Index VII & VIII and because of serious illness in the staff. The Library had planned to complete this index during 1952. Under present financial and personnel conditions this volume will have to be postponed indefinitely.

Index X (1950)

Completed and in process of typing.

Index XI (1951)

Current indexing has been maintained. This index will be closed on Dec. 31, 1951 and revised for typing.

The volume of published material in the field of applied entomology continues to increase. At the same time it is becoming steadily more complex and therefore more difficult to index satisfactorily, with the result that even a competent and experienced person can cover less ground now than ten or fifteen

years ago. To some extent the indexing now carried on is already selective but we believe further restriction of coverage is possible and practicable and that it would not result in seriously impairing the usefulness of the Indexes. At the same time it must be recognized that this project may demand increasing financial support from the Association itself.

We believe the Indexes have proved themselves and that they should be continued, and we suggest that this committee (if it still exists), or another, be instructed to work out immediately a practical plan for the continuance of the preparation of the Indexes under present emergency conditions. Since this would necessarily involve material reduction in literature coverage the committee should be empowered to decide what publications are to be indexed and to what extent further selective indexing should be practiced.

INA L. HAWES
B. A. PORTER
C. F. W. MUESEBECK, *Chairman*

REPORT OF REPRESENTATIVE TO THE NATIONAL RESEARCH COUNCIL DIVISION OF BIOLOGY AND AGRICULTURE

The annual meeting of the Division of Biology and Agriculture was held on May 15, 1951 at the National Academy of Sciences.

Various reports by committees of the Agricultural Board dealt with a number of unrelated subjects. Those of possible interest to entomologists included:

a. Public Health Aspects of Brucellosis
b. Animal Health with Particular Emphasis on Hog Cholera and Its Elimination.
c. Regulations Governing Animal Nutrition and the Nutrient Allowances for Common Domestic Animals and Poultry.

A newly formed committee is arranging for the preservation of indigenous strains of corn in Latin America which natives are replacing with newer varieties. These strains originally grown in those countries are desired by hybridizers for further breeding work in this country.

A committee on scientific manpower reported progress in the national plan to defer from military duty those college students found qualified by examination. This committee furnished much background material that led up to the Presidential Proclamation relative to the deferment of students. It now appears that training of scientific man power will not be seriously affected by the military.

Among the activities of the Food and Nutrition Board is the establishment of a Committee on Food Protection. This committee, supported by funds from industry, was formed in response to public concern regarding the increase use of chemicals in food processing and pest control. The subcommittee on pesticides includes George Decker and H. L. Haller of our Association. This committee, appointed by the National Research Council, an unbiased organization, should help to reconcile the divergent viewpoints of chemical manufacturers, food processors, Government agencies and the general public.

Several resolutions were passed.

One was a petition to Congress to appropriate funds for American scientists to travel abroad.

Another urged the passing of legislation to permit full use of dogs for experimentation. It proposed a law forbidding all vivisection except under license. This plan which reduces objections by antivivisectionists is operating satisfactorily in New Jersey and England.

Your representative served on the screening selection committee of the Conference Board of Associated Research Councils' Committee on International Exchange of Persons. A screening committee examined 26 applications for Fulbright Awards to be granted for research or lecturing in foreign countries in 1952–53. Biologists, zoologists and entomologists were among the applicants.

After serving on this screening committee it is now realized that, according to stipulations of the Fulbright Act and the accompanying requirements for acceptance, the opportunities for entomologists to study abroad on Fulbright Fellowships are limited.

If one does apply for a fellowship there should have been a request for the work from a foreign country. Also one should have proper personal qualifications, be near the 35 year age group, have a doctorate degree and also a record of good research papers. Finally opportunities for doing research on your problem should be better abroad than at home.

Respectfully submitted,
FLOYD F. SMITH

REPORT OF ANNUAL MEETING OF JOINT COMMITTEE ON GRASSLAND FARMING

Following receipt from C. B. Bender, Chairman, Joint Committee on Grassland Farming, of an invitation to the American Association of Economic Entomologists to affiliate with that group, the undersigned was designated by President Campbell to act as an informal representative of the AAEE, pending action on the invitation by the Executive Committee meeting in Cincinnati, Ohio, December 10, 1951.

The annual meeting of the Joint Committee on Grassland Farming was held in Chicago, Illinois, November 28, 1951. Literature on the background highlights of the Committee and a proposed revision of the bylaws were distributed at Chicago, and copies are appended for Executive Committee Consideration. The major activities of the Joint Committee are reflected in two publications, "Green Fields Are Gold" and "Grassland Livestock Handbook," copies of which are also appended. There has been no previous participation by entomologists in the affairs of the Joint Committee, but Chairman Bender advised that the part that entomology can take in furthering the objectives of the Committee is considerable, and he was hopeful that the invitation extended to the AAEE would receive favorable consideration. Future publications by the Committee are anticipated, and discussions of entomological problems should appear therein.

It appears that the objectives of the Grassland Committee are compatible with those of the AAEE, and that affiliation with the group would provide an opportunity for recognition and advancement of our profession generally. Accordingly, it is recommended that the Association accept the invitation of the Committee to affiliate with their group, and that a permanent representative of the Association be appointed to function on the Committee.

Respectfully submitted,
W. A. BAKER
Temporary Representative for the AAEE

REPORT OF SPECIAL COMMITTEE AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

Publication Policies

On August 31, 1951, we were appointed by President Campbell to consider, among other matters, changes in our publication policy, especially in regard to the publication of invitation papers and papers by nonmembers, and the publication of a monthly bulletin.

As a starting point for its discussions, the committee used a report made at the Tampa meeting in December, 1949 by the Publications Committee, headed by S. E. Flanders. In considering the whole subject, however, certain changes in the By-Laws seemed needed to provide a more workable basis for the publication activities of the Association. Such changes are included in a proposed revision of the Constitution and By-Laws discussed in another report. Provision is made for the publication of a monthly bulletin, although any decision on it should be made by the Governing Board.

Many of the points in the Flanders report did not appear to belong in the Constitution or By-Laws. We have therefore included these points in a proposed statement, "Publication Policies and Rules of the Journal of Economic Entomology."

We have made an effort to liberalize the rules governing the acceptance of invitation and other non-member papers when the best interests of Economic Entomology would be served thereby. However, we feel that invitation papers should, of course, meet Journal standards.

There has been some doubt of the desirability of the reinstatement of the six-page limit for papers and a one-page limit for Scientific Notes. Such limits, however, have been retained in our report.

C. F. W. MUESEBECK
H. M. HARRIS
J. L. HORSFALL
HARLOW B. MILLS
B. A. PORTER, *Chairman*

PUBLICATION POLICIES AND RULES OF THE JOURNAL OF ECONOMIC ENTOMOLOGY

Papers acceptable for publication in the JOURNAL OF ECONOMIC ENTOMOLOGY shall as a rule consist of progress or final reports on original biological or biochemical research and its application in the field of applied entomology and closely related fields, including quarantine activities. Other papers dealing with economic entomology, such as papers reviewing the status of important insect problems, or reports on large-scale control activities, may be accepted in the discretion of the Editor.

Papers (including Scientific Notes) by nonmember authors who are regularly employed as entomologists may be accepted for publication under the condition that publication costs are paid. This requirement shall not apply to invitation papers included in the sessions of the association. If they are otherwise acceptable they may be published free. Other papers by non-members may be published free upon approval by the Editor and majority vote of the Publications Committee. Free publication by members shall be limited to six Journal pages for each Article and one Journal page for each Scientific Note.

In the consideration of papers, an important factor shall be the value of such papers in the field of economic entomology. If the Editor's decision is challenged, he shall refer the matter to the entire Publications Committee.

Reports concerning compounds of technical grade or concerning formulations or proprietary products should state the active constituents and and the percentage present. Papers are not acceptable that are concerned with compounds that are chemically unidentified or insufficiently characterized.

All papers by members of the Association accepted for free publication shall be published in approximate order of their receipt by the Editor. The date of receipt of a research article or note in acceptable form shall be published with the article.

In general no paper which has already been published either wholly or in essential part in a Journal which has general circulation among economic entomologists may be accepted for publication in the JOURNAL OF ECONOMIC ENTOMOLOGY, excepting that mimeographed papers, invitational addresses and symposia may be published if they meet the standards of the JOURNAL OF ECONOMIC ENTOMOLOGY and are approved by the majority of the Publication Committee.

Each paper must be reviewed by and receive the approval of at least one member of the Publications Committee. Papers are unacceptable if conclusions are obviously unsound or are based on faulty experimental methods on inadequate data. Acceptable papers must be in accord with the rules and suggestions printed in each issue of the Journal. When a committee member receives for review a paper which is outside his particular field he shall submit the paper to some person whom he considers qualified to evaluate it. The evaluation thus obtained shall form the basis of the committee member's recommendation. When the Editor or Associate Editor and one member of the Committee find that a paper is unacceptable, the Editor shall promptly return it to the author with a statement giving the reasons for its nonacceptance.

A paper acceptable for publication which would occupy less than two pages of the JOURNAL OF ECONOMIC ENTOMOLOGY in 10-point type, including illustrations or tables, shall be published as a Scientific Note except as may be agreed upon by the Editor and one member of the Publications Committee.

The publication of scientific notes should be approximately in order of their receipt, but independent of that of the articles. An abstract of a paper presented at the annual meeting, however, may be published as a scientific note in the first subsequent issue of the Journal. Titles of scientific notes shall be included in the table of contents, and shall be indexed.

The title of a paper should be short and concise.

The author (or authors) of a paper shall receive two printer's proofs for necessary changes and shall return a corrected proof to the Editor.

COMMITTEE ON RESOLUTIONS

Your Committee on Resolutions submits the folling report:

I. *Whereas:* The members of the American Association of Economic Entomologists in attendance at the 63rd Annual Meeting of their Association at Cincinnati, Ohio during the four day period ending December 13, 1951 have enjoyed the renewal of old friendships and the formation of new ones and have profited from the exchanges of ideas so essential to the welfare of entomological science;
Be it therefore resolved: That the Association express its appreciation to the following individuals and agencies that have been responsible for the success of this occasion,
(a) The local arrangement committee: C. R. Cutright (Chairman), T. H. Parks (acting chairman), Annette Braun, W. A. Price, R. H. Davidson, M. W. Boesel, J. N. Knull and D. M. DeLong.
(b) The Program Committee: L. D. Christenson (Chairman), Howard Baker (acting chairman), H. G. Johnston, and C. E. Mickel.
(c) The secretaries and presiding officers of the general and sectional sessions.
(d) The administration and operational personnel of the Netherland Plaza Hotel.
(e) The officers and members of the cooperating organizations, the Entomological Society of America, the American Phytopathological Society and the Potato Association of America.
(f) The guest speaker at the dinner, Dr. Isa Balinkin.

II. *Whereas:* The serving of honey in this Annual Meeting was a highly appropriate gesture;
Be it therefore resolved: That the serving of honey at Association banquets be established as a custom.

III. *Whereas:* The Association during the past year has suffered through death, the irreparable loss of the following members: S. A. ROHWER, JR., S. E. CRUMB, H. L. DOZIER, H. E. EWING, CLIFTON B. HITT, H. J. QUAYLE, NEALE F. HOWARD, DUDLEY MOULTON, HAROLD I. O'BRYNE, W. A. THOMAS, W. H. WHITE and E. F. PHILLIPS.
Be it therefore resolved: That we place on record our great appreciation of the contributions the members have made to the science of entomology and the welfare of our Association and our great sense of loss upon their leaving us. That our association extend our sincere sympathy to the bereaved families.
Whereas, the matter of an adequate defense against the possible hostile introduction of dangerous insect pests is of vital concern to American agriculture; and
Whereas, the State Civil Defense Directors in each state may have need for the professional services and advice of competent entomologists in the production of food and fiber and the conservation of forests.
Whereas, appropriate state agencies have designated a qualified specialist as leader of insect pest surveys in each state, therefore
Be it Resolved, that the American Association of Economic Entomologists urges the State Civil Defense Directors, in the interest of economy and efficiency to appoint these same experienced and well qualified leaders to similar posts in the state civil defence organizations.
Be It Further Resolved, that this Association respectfully request the Federal Civil Defense Administration to encourage and support such a proposal not only with respect to entomologists but also in the case of plant pathologists, veternarians where such groups already have an organized program established for the detection of new pests and the protection of agriculture.

I. H. GILBERT
B. B. PEPPER
NEELY TURNER
STANLEY E. FLANDERS, *Chairman*

EXECUTIVE COMMITTEE REPORT DECEMBER 9, 1951

1. The Auditors report was accepted on motion of Porter, Sec. by Reed.
2. The report on Index VIII was presented by Porter. The committee ordered that a vote of thanks be transmitted to Miss Hawes, the other members of the committee and to others who contributed. The committee consisting of Miss Hawes, Porter and Muesebeck was continued to supervise the issuance of subsequent issues. The situation with regard to the indexing for 1948 and 1949 was to be called to the attention of Mr. Hoyt with the request that he do all that is possible to further the completion of the indexing for those years. The Executive Committee approved a bargain sale of Index VIII to members for the one month ending February 1, 1952.
3. The Executive Committee approved, with certain changes, the draft of a new constitution which will be read at the final business session.
4. The approved statement of policy with regard to publication will be read at the final business session.
5. The committee authorized the incoming president to appoint a liasion committee to work with the American Chemical Society, the American Medical Association and other groups in presenting matters relating to entomology before Congressional committees.
6. The incoming President was directed to appoint a committee to prepare a brochure on vocational information in regard to the profession of entomology, to be distributed to the many agencies now seeking such information.
7. Philadelphia was selected for 1952. The schedule was revised by moving the tentatively scheduled date for the South or Southwest up one year to 1954. The Pacific meeting will probably be at Los Angeles in 1953.
8. The list of members will be published in the February Journal and thereafter every 2 years.
9. The subscription price of the Journal was set at $5.00 for members and $10.00 for nonmembers to become effective in 1953. Ratification of this increase will be voted upon at the final business session.
10. The editor, Dr. G. S. Langford, and his committee were commended for their efforts in regard to *Entoma.*

REPORT OF THE REPRESENTATIVE OF THE AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS TO THE NATIONAL CONFERENCE OF NON-GOVERNMENTAL ORGANIZATIONS ON FAO

Meeting of conferences of Non-Governmental Organizations of FAO held in Washington, D. C., on May 10 and October 19, 1951, were attended by the writer. These conferences were convened under the joint chairmanship of John C. Lynn and Persia Campbell. A steering committee of this organization which was set up previously also had one or more meetings during the year. The organization is composed of representatives of about 100 scientific, industrial, educational, political and religious organizations. The general purpose of the Non-Governmental Organization is to guide and support the Food and Agricultural Organization. The organization issues a news letter which summarizes its major activities.

Secretary Brannan and Under-Secretary McCormick and other members of the Department staff as well as Director General Dodd addressed the group.

Various matters relating to the FAO program throughout the work were discussed particularly with reference to long term trends and policies. At the last meeting much attention was given to ways by which the organization could increase public understanding of FAO and how FAO's hand in world affairs could be strengthened. The technical assistance program, commodity problems, land reform, the relation of FAO to other United Nations Agencies and FAO's budget were presented by members of the conference and each was discussed at some length.

It seems appropriate that members of the A.A.E.E. become familiar with the program of FAO and lend assistance to its program in various parts of the world. This can be done by supplying technical information, aiding in procurement of competent entomological personnel and by helping to inform the public the part entomology can play through FAO by increasing world production and improving public welfare.

F. C. BISHOPP

REPORT OF THE AMERICAN COMMITTEE ON ENTOMOLOGICAL NOMENCLATURE

The committee met at the annual meeting (1950) held in Denver. Although no nomenclatorial problems had been submitted to it, it was decided that the committee should be continued for the present.

We wish to report for confirmation the membership as indicated below:

1951	MICHENER, WALLEY, OMAN
1952	CAZIER, LINSLEY, SABROSKY
1953	BRADLEY, MUESEBECK, USINGER

The class of 1953 was elected in 1950, that of 1952 in 1949, that of 1951 in 1948.

Officers elected are:

President: E. G. LINSLEY
Secretary: C. D. MICHENER

Respectfully submitted,
CHARLES D. MICHENER, *Secretary*

REPORT OF THE JOINT COMMITTEE ON THE PREPARATION OF A HISTORY OF ENTOMOLOGY DURING WORLD WAR II

The first draft of the History was completed by the editor, Colonel E. C. Cushing during the current year. Colonel Cushing met with Major P. W. Oman, Chairman, and E. F. Knipling, Co-chairman, of the joint committee in Washington early in the year to review the draft. Certain suggestions were offered and the editor has submitted a second draft which is now being typed. This draft will be distributed and reviewed by all members of the committee. It will also be submitted to others for suggestions and criticism.

Two members of the committee, Major P. A. Oman and Lt. Col. R. A. Bunn are on assignment in foreign countries. The absence of these members of the joint committee has naturally been a handicap to the editor and to the committee in completing the history. However, a copy should be in the hands of the Executive Committee early in 1952.

The committee feels that Colonel Cushing is to be commended for completing the first drafts of the History under extremely difficult circumstances.

STANLEY W. BROMLEY
RALPH W. BUNN
E. F. KNIPLING, *Co-chairman*
PAUL W. OMAN, *Chairman*

FINAL BUSINESS SESSION

There were approximately 300 members present at the final business session.

The draft of the new constitution and by-laws with the change in name of the Association to The American Association of Entomologists was read by B. A. Porter but no vote was taken inasmuch an agreement had been reached with the Entomological Society of America to give them until June 1, 1952 for a re-ballot on the consolidation which was lost on the first ballot by 1.6 per cent. If upon re-balloting that Society approves consolidation, the name, Entomological Society of America, will be accepted for the new organization and the constitution and by laws as published and circulated last year will be the rules under which the consolidated organizations will operate.

If the Society rejects consolidation, the constitution and by laws of the American Association of Entomologists as read at this session will be printed and circulated for a letter ballot of approval.

The new prices for the Journal were approved to take effect in 1953.

THE NINTH INTERNATIONAL CONGRESS OF ENTOMOLOGY

By J. CHESTER BRADLEY

Under the patronage of Her Majesty, Queen Juliana of the Netherlands, the Ninth International Entomological Congress was held at Amsterdam from Friday the seventeenth to Saturday the twenty-fifth of last August (1951).

The heart of Äm-ster-däm', as the Dutch pronounce it, is the spot where the Lord of Amstel in 1204 built his castle and a dam on the river of that name. It is still called just the Dam. Streets and some canals radiate from it like a gargantuan spider's

web, binding together concentric canals that were once the moats of successive walls of the ever expanding city. In the ancient residential quarters these broad canals, called grachts, are flanked on each side by pleasant, elm-shaded streets. Handsome old patrician houses, built of brick in the peculiar Dutch style of the 17th and 18th centuries stand shoulder to shoulder along them. But how the wealthy burghers are gone and their fine houses, though their exteriors are not changed, are occupied by offices or commercial firms. All buildings stand on piles, which caused Erasmus to speak of a city whose inhabitants dwell on the tops of trees, like rooks. Unlike Venice, with which it is often compared, its 400 bridges permit vehicular traffic, and the canals are not used for passengers. As the power and glory of Venice declined, that of Amsterdam rose, until by the seventeenth century it had become the most important mercantile city in Europe.

Today Amsterdam is the center of science and of art in the Netherlands. So many congresses are held there that the people have become very adept, know precisely how to make the most perfect arrangements, and have every necessary facility. There are excellent hotels, but, as in other European cities, none on the scale of the Netherland Plaza. Prior to arrival each congressionist had been assigned to a room in one of the many hotels, of the grade that met his requirements, some, by preference, to rooms in private homes.

The Congress was held in the Royal Institute for the Tropics, a private foundation. The importance of this institute to the Netherlands will be appreciated by all who realize how essential their tropical possessions have been to the economy of the nation, correspondingly, what a blow the loss of the East Indies is proving. The industries, natural history and ethnography of all Dutch overseas possessions or former possessions are illustrated by attractively arranged modern exhibits in the handsome Museum building. The Institute has three departments: Tropical Hygiene, Anthropology, and Tropical Products.

The charm of Amsterdam was felt by all as we assembled for the opening of the Congress. The butterfly *Chrysophanus dispar*, emblazoned in orange on two banners floating in front of the imposing group of buildings of the Institute for the Tropics was a sure signal to those gathering that they had found their way. In the registration hall each member received his badge and an envelope of papers and pamphlets. The badge bore the insignia of the Congress, a replica of the butterfly emblems on the two banners, done in color on a porcelain disk. Among the papers handed us were numerous invitations and tickets, programs, abstracts, a membership list, and three notable pamphlets: A list of all institutions and societies in the Netherlands of interest to biologists, a 68-page account of the Netherlands as an environment for insect life, with detailed descriptions of its biotic communities, and a historical account of the history of Entomology in the Netherlands and their overseas territories. In this registration hall we found that every member was provided with a mail box, that there was a bank, a travel bureau, and a post office, and on the floor below a lunch room. Provision was even made for those who collect stamps, by using a special cachet on all mail posted in the hall. In this lobby there was an exceedingly attractive entomological exhibition. Old and rare Dutch books were on display, material illustrative of papers that were to be read, and other matters of technical interest. There were also exhibits by Reitter of Munich, formerly of Vienna, of Wilhelm Junk, the publisher and others.

Speaking of Junk, those who later took the excursion to Leyden were entertained for tea in the Hague at the residence of Mr. Weisbach, the present proprietor of the firm, son-in-law of Wilhelm Junk. Tea tables had been arranged in the garden. There were large cakes baked to resemble fruit-chafers very realistically; icing, decorated with a proper color pattern, served as integument, while legs and antennae were realistically molded from chocolate. These had to be cut to be served, but everyone also received cookies made to resemble caterpillars with chocolate heads.

The opening session of the Congress was held in the great auditorium of the Institute. Dr. D. J. Kuenen, professor of Zoology in the University of Leyden, was president. No more perfect presiding officer could be imagined. His ability to switch from fluent English to French and then to German, the three official languages of the Congress, was something to be envied. The Minister of Home Affairs opened the Congress with an address of welcome, and a lecture by Professor Schwellen-Grebel, Director of the Division for Tropical Hygiene, followed.

That evening there was a social gathering, at which we began to renew old acquaintances, and to make new ones. Americans who recall the congress held at Ithaca in 1928 would have found a number of old friends present: First of all, Dr. Karl Jordan and his daughter, he now over 90, Honorary President of the Entomological Congresses, prime mover in their initiation, and who probably has attended them all; Dr. Rene Jeannel, recently retired as director of the Museum d'Histoire naturelle of Paris, chairman of the permanent committee of the Congresses, and N. D. Riley of the British Museum, its secretary. Amongst others who were with us in '28 were Efflatonn Bey of Cairo, Vayssiere of Paris, Cebellos of Madrid, Natwig of Oslo, Corporaal of Amsterdam, Roepke of Wageningen, Kryger of Denmark, Saalas of Helsinki, Regnier of Rouen, and Richards of London.

Eight hundred and five persons registered, but not all attended. They came from 52 countries, if one includes colonial possessions. One hundred fifty, a fifth of the total, had to make extensive overseas journeys, 61 of these from North America.

Netherlands naturally led in number of registrations, with 203, then followed Great Britain with 151, Germany with 82, the Scandinavian countries including Finland with 73, the United States together with Canada, 61, France with 56, Belgium with 33, and Switzerland with 29. No other country had over 11. There were eight registrations from behind the iron curtain, but none from Russia.

Later in the evening Dr. Lieftink showed some marvelous coloured moving pictures of insects in Java, graceful Mecistogasters, and brilliant dragonflies in tropical glades. The most incredible was the portrayal of the antics of a mantid.

There were fourteen sections that met simultaneously for symposia and the reading of papers. In the front of each meeting-room there was a board with a column of figures for each of the other sections. These figures represented the numbers by which the papers to be read in each section were designated on the program. As soon as any paper was completed, word was received by telephone in

every other section-room and in the main hall, and attendants removed its number from the boards.

The way in which paper-reading sessions were interspersed with excursions and with social events relieved all fatigue coming from too much listening. On the last evening we were entertained in the City Opera House by a performance of Carmen, followed by an elaborate supper at a nearby restaurant. After this came entertainment of a vaudeville nature, and then dancing throughout what little was left of the night.

I shall leave it to Dr. Glen to speak of the more scientific aspects of the Congress, of the program, of the excursions and the many social events. But before I yield the platform to him, I must speak of an incident which illustrates the meticulous care with which every detail of the Congress was planned long in advance. The Netherlands Entomological Society entertained the entire Congress at a lunch in the old and famous Krasnapolsky restuarant. I learned that the committee in charge had met at that restaurant 10 months before and were served precisely the same selected menu. Then, being completely satisfied, they had exacted a guarantee from the management that it would be as faultlessly prepared when served to 800 as it had been to ten!

Is it any wonder that the Congress was a grand success? But now—Dr. Glen.

A Report on the Ninth International Congress of Entomology

ROBERT GLEN

Chief, Division of Entomology, Ottawa, Canada

Dr. Bradley has given you an excellent description of the physical setting and the general atmosphere surrounding the Congress in Amsterdam. I shall restrict my remarks largely to the program proper and to a few general impressions gained from personal discussions.

In planning the program, the local committees stressed variety and carried into practice the old adage: "A change is as good as a rest."

There were two general sessions, one near the beginning and one near the end of the Congress, at each of which two invitation papers were read. All other papers were presented at the fourteen topical sections (taxonomy, physiology, insecticides, forest entomology, etc.) that met concurrently. Each section had a Netherlands entomologist as leader and he took primary responsibility for the planning of the section's activities. Only twice during the Congress did any section meet on successive half days; and all but three sections (Nomenclature, Stored Product Insects, and Medical and Veterinary Entomology) held at least one symposium session. Excursions to typical Netherlands habitats or to scientific centres were arranged on four days during the conference, and on each of these days a remarkably wide choice of trip was offered. On days without excursions special social events were scheduled. Reference has already been made by Dr. Bradley to the opera party, the luncheon provided by the Netherlands Entomological Society, and the special film evenings. Other memorable occasions were the conducted boat trip through the canals and harbour of Amsterdam, the section dinners, and the reception in the State Museum sponsored by the Netherlands Government and the Municipality of Amsterdam. The art collection in the State Museum includes numerous fine originals by such masters as van Eyck, Rembrandt, Hals, Maes, and Hobbema; and on this occasion the entire gallery was opened to the Congress members.

Two events of considerable entomological significance, but wholly independent of the Congress, were superimposed on the regular program: the first, a special meeting of the Lepidopterists' Society featuring a symposium on "The phylogeny and the classification of the Lepidoptera"; the second, an extended session of the International Union of Biological Sciences for discussions on "Symbiosis in Insects."

In short, our Dutch hosts, by means of judicious planning, arranged with admirable success for the presentation of nearly 300 scientific papers, visits to key institutions, an introduction to Dutch culture, and repeated opportunities for the all-important person to person discussions among those attending the Congress.

Time will not permit of extensive reference to specific papers. I should like, however, to comment briefly upon three topics of general interest that received consideration at the Congress. In each case I shall emphasize the viewpoints of entomologists from countries other than the United States and Canada.

The effect of light on diapause in insects is a popular subject in Europe today. Apparently, Dr. Michael Way, formerly at Rothamsted Experimental Station, was among the first entomologists in England to call attention to photoperiodism. He discovered that if larvae of the tobacco moth, *Diataraxia oleracea* L., were exposed to 16 hours of light each day during the last larval stage, diapause did not ensue; whereas with exposures of half this duration diapause invariably followed. At Cambridge, A. D. Lees and W. A. L. David are following up this lead, working respectively on the European red mite, *Metatetranychus ulmi* (Koch) (=*Paratetranychus pilosus* C. & F.), and the cabbage white butterfly, *Pieris brassicae* L.

By adjusting the photoperiod in the last larval instar of *Pieris brassicae* L. Dr. David prevents pupal diapause and has succeeded in rearing five to six generations in a year. A photoperiod of 16 hours suffices for the complete suppression of diapause.

Dr. Lees reported to the Congress that in the European red mite the production of winter or diapause eggs instead of summer or non-diapause eggs is determined by the conditions to which the mother mite is exposed during her last larval instar. The factors concerned in the induction of diapause are photoperiod, temperature, and nutrition. At medium temperatures of say 15° C. and illumination (intensity in excess of 10–20 lux) for 16 hours daily, only non-diapause eggs are produced. In contrast, when the photoperiod is less than 12 hours only diapause eggs are laid. Higher temperatures favour the production of the diapause condition and lower temperatures of the non-diapause state. Inadequate nutrition, as judged by restricting the available food to senescent or mite-damaged leaves, diverts the development towards the diapause condition even when the factors of light and temperature are favourable for the production of non-diapause eggs. Strangely enough exposure to continuous light induces diapause and to continuous darkness, non-diapause.

Organic phosphorous insecticides were the subject of several communications at the Congress, including a special symposium in Section XIII and a most enlightening address by Dr. G. S. Hartley of Pest

Control Limited, Cambridge, England, which was presented during the excursion to Philips-Roxane Field Research Station at Boekesteyn.

Dr. R. M. Greenslade, England, and others drew attention to the fact that systemic insecticides react chemically with substances in the sap and other tissues of treated plants. In consequence the physiological condition of the plant and its normal seasonal changes affect the performance of such insecticides. Since insect feeding habits also vary seasonally, it is not surprising that dissimilar results arise from systemic insecticides applied to the same variety of plant in different seasons of the year.

Dr. Hartley discussed the chemistry of the subject. Apart from the basic requirement of toxicity to insects he listed three essential characteristics of a systemic insecticide: (1) it must be water soluble, and the weak systemic action of parathion is directly attributable to its relative insolubility in water (20 p.p.m.); (2) it must be fairly stable in water, otherwise it is rapidly hydrolyzed into non-toxic products; and (3) it must be able to penetrate into the sap stream through the leaf or root cuticle.

Radioactive tracers coupled with suitable partition techniques have been employed to study absorption and decomposition of systemic insecticides. Biological factors such as plant species, stage of growth, intensity of assimilation, and water status are reported to be important for penetration. External physical factors are likewise effective, radiation being regarded as much the most significant.

Once the insecticide is absorbed, the duration of toxic residues varies with the material applied and with the plant and its metabolism. In general, decomposition occurs readily, especially in young plants. Most of the decomposition products are not toxic to insects or mammals although anticholinesterase substances have been demonstrated to occur in limited quantities in the sap of plants treated with phosphorous-containing systemic insecticides. It is very probable that this same intermediate product is formed in much greater quantities in animal bodies than in plants and that it is the compound really responsible for the toxic action in both insects and mammals. This decomposition of systemic insecticides within plants and animals is suggested by Dr. Hartley to be initiated by enzymatic oxidation of the dimethylamino groups.

The latest systemic insecticide developed by Dr. Hartley is Isopestox or bis (monoisopropylamino) fluorophosphine oxide. It is much less selective than Schradan; has a pronounced contact effect on aphids and red spider; and is rapidly decomposed in the plant to harmless products, and so is less hazardous to warm-blooded animals.

Insect pest surveys are receiving increased attention in Great Britain. According to A. H. Strickland, British authorities are asking: At what infestation levels are insects of sufficient crop hazard to justify applications of chemicals? Careful and extensive investigation is needed to provide a reliable answer and Mr. Strickland has been assigned this task.

He proposes to begin with a study of one pest, the cabbage aphid. Records will be taken from eight cabbage fields, one in each of the provinces organized under the National Agricultural Advisory Service. In each field, test plots of 10×20 yd. will be laid out in the form of two adjacent latin squares. Each square will have duplicated checks and chemically-treated plots.

Estimates of aphid abundance will be made in each plot every fortnight throughout the growing season. For this purpose three leaves will be taken from each of 50 cabbage plants. Each group of 150 leaves will be put into a churn half-filled with water. After rotating for a given period the churn will be drained, the water passing through a cheesecloth bag where the aphids will be caught. This washing procedure will be repeated if necessary. The aphids collected will be counted by an electronic device which is still under development. All aphids in a collection, or a representative sample of them, will be photographed and the developmental stages will be recorded from an examination of the negatives on a film reader.

Assessment of damage will be made from a comparison of cabbage yields in plots of different population levels, particularly between treated and untreated plots.

The study is planned for a 5 year period. It is hoped that enough information will have been obtained by then to show whether the aphid is of economic importance every year in every province. Ultimately other important pests will be studied in a corresponding manner and eventually there willl be developed a practical survey system based on sound statistical concepts.

General impressions, like scientific generalizations, are fraught with danger; but they are also the beginnings from which we proceed towards refinement of ideas and knowledge.

My first impression is that entomologists in Europe attain research competence at an earlier age than in America. This observation undoubtedly is linked with another impression: that European entomologists in general are better oriented scientifically in regard to their problems and have clearer working concepts than have their American counterparts. If these views are sound, we are fortunate, for it means that we can still obtain assistance from our more experienced progenitors in our efforts to improve the working principles of our science.

Europeans still regard Americans as extremists in their liberal use of non-selective, potent insecticides. However, I found the Europeans to be just as extreme in their own faith in biological control agents. Probably both practices are justified in large measure. Conditions for extensive insect outbreaks have been and still are far more favourable in America where vast stretches of land are utilized for the production of one crop or a few related crops. Under these circumstances drastic control measures must frequently be condoned. In contrast, the general practice in Europe is to cultivate a great diversity of crops within a relatively small land area. This practice maintains a greater variety of insects and in consequence a greater abundance of secondary hosts for parasites and predators. Consequently, with admitted exceptions, biological agents undoubtedly do exert a much more permanent influence in most of Europe than they do in most of the United States and Canada. However, in Europe, as in America, the trend is towards a combination of cultural, chemical, and biological measures. This of course is a very big order and achievement will be slow, especially in America where the insect pest problems are much more formidable.

Many Europeans still regard entomology as being strongly on the applied side in America and mainly along theoretical lines in Europe. Be that as it may, the really important point is that applied entomology is gaining scientific recognition among Europeans. Dr. Wigglesworth has previously expressed

his respect for the role of the applied worker; and at the Congress Drs. Regnier and Trouvelot of France stated (free translation): Thanks to the influence of such renowned biologists as Riley, Howard, Berlese, Escherich, Marchal, and Silvestri, the platonic conception separating pure and applied science has faded away and applied entomology can take its place with other general sciences, a place that no one will contest now. The great trend in applied entomology today, the world over, appears to be the team approach, the joining of forces not only among specialists in various fields of entomology but also with specialists in related sciences: chemistry, physics, engineering, plant physiology, etc. This development certainly is narrowing to the vanishing point any gap, real or imaginary, that existed previously between the theoretical and the practical aspects of entomology.

The Tenth International Congress of Entomology will probably be held in 1955, but the locale has not been decided. Among the factors affecting this decision is foreign exchange. This difficulty ruled out any serious consideration of holding the next meeting in Canada. However, by a peculiar twist of circumstances Brazil has become a strong contender for the Tenth Congress in spite of similar currency problems.

In the meantime those of us who were privileged to attend the Amsterdam meetings will continue to enjoy happy memories. It is distinctly a pleasure to reminisce on the subject and Dr. Bradley and I both thank you for this opportunity of doing so.

REPORT OF THE INTERNATIONAL CONGRESS OF ENTOMOLOGY AT AMSTERDAM

The Ninth International Congress of Entomology under the presidency of Dr. D. J. Keunen was held in Amsterdam, the Netherlands, August 17 to 24, 1951. The Congress was officially opened on the morning of August 17, by His Excellency, Mr. J. H. van Maarseveen, Minister of Home Affairs of the Netherlands, followed by addresses by the President of the Congress and by Professor N. H. Swellengrebel, of the Laboratory of Tropical Hygiene of Amsterdam.

Excellent accommodations were provided for the sessions of the Congress in the Institute for the Tropics. There were daily general sessions at which many interesting addresses were presented by noted entomologists. There were also sections for systematics and morphology, nomenclature, genetics and ontogeny, physiology, ethology (analytical behavior studies), ecology and biology, zoogeography, agricultural entomology and beekeeping, forest entomology, tropical agricultural entomology, stored products, and medical and veterinary entomology, insecticides and insecticidal technique, and Arachnoidae. The sectional programs included a number of symposia.

At the Congress, representatives were present from 38 different countries including about 25 entomologists from the United States and Canada. The total registration was 817. The official languages of the Congress were English, German, and French.

A number of social entertainments were arranged for the pleasure of the delegates including an official reception by the Netherlands Ministers and the Burgomaster of Amsterdam, in the Rijskmuseum. Several very instructive excursions were made to places of interest, including the sand dunes at Groet on the North Sea coast to afford an opportunity to collect insects, and a whole day trip to the Agricultural University at Wageningen. A number of buildings of this University were destroyed or damaged during the battle of Arnhem. New buildings included a plant science wing, entomology and plant pathology laboratories and greenhouses, all with up-to-date equipment.

Contributions of value to the science of entomology were presented at the Congress, particularly in insect physiology. It was a real pleasure to meet again many of the prominent entomologists of Europe, and in addition develop new friendships. All who attended the Congress are deeply indebted to the Dutch Committee for arranging events with clock-like precision, for providing translators and interpreters and doing everything possible for the convenience and comfort of the delegates.

An invitation was received to hold the Tenth International Congress in Brazil in 1955, the date and place to be finally established by the Permanent Committee.

Following the Amsterdam Meeting, a number of delegates visited the reclamation projects of the Zuider Zee and other places of interest, special arrangements for which had been made by the local committee.

ALBERT HARTZELL

REPORT ON THE FOURTEENTH INTERNATIONAL BEEKEEPING CONGRESS

The Congress was held at Leamington Spa, England, Sept. 3–8, 1951. Members from 24 countries, some 309 people, registered for the Congress. The following people were responsible for the tremendous task in organizing the Congress. Miss Nancy Ironside, the Organizing Secretary, W. B. Williams, Chairman of the British Beekeepers Association, D. S. Hudson, Treasurer, and Dr. R. H. Barnes, the President. Certainly the name of Mlle. Nora Baldensperger, who translated so ably and tirelessly throughout the Congress must be added to these others.

TUESDAY, SEPTEMBER 4

President's Remarks; followed by the paper-reading sessions, demonstrations, films and excursions which continued through Saturday, September 8. The papers included the following groups:

1. Papers on POLLINATION AND SPRAYING PROBLEMS
   Chairman: *Dr. C. G. Butler.* (England)
2. Papers on SCIENTIFIC COLONY MANAGEMENT
   Chairman: *Dr. O. Hammer.* (Denmark)
3. Papers on BEE BREEDING
   Chairman: *C. J. McKinley Kridge.* (England)

WEDNESDAY, SEPTEMBER 5

A whole day excursion to the Royal Agricultural College, Cirencester.

1:30–2:30 P.M., Program Papers and Outdoor Demonstrations.

THURSDAY, SEPTEMBER 6

4. BEE DISEASES
   Chairman: *Dr. O. Morgenthaler.* (Switzerland)

Honey Show in Masonic Rooms.

Apis Club meeting.

Bee Research Association—Paid up members.

FRIDAY, SEPTEMBER 7

5. NECTAR, POLLEN, HONEY AND BEE PLANTS
Chairman: *Dr. A. Minderhoud.*
6. BEE BEHAVIOUR AND PHYSIOLOGY
Chairman: *S. Gooding*
HONEY SHOW OPEN ALL DAY

SATURDAY, SEPTEMBER 8

7. OPEN SESSION—FILMS
Chairman: *Miss N. Ironside.* (England)

This completed the Congress proper. However, two busloads of members left on Saturday morning for a visit to the apiaries at Buckfast Abbey where Brother Adam is in charge of one of the world's leading private bee research centers.

The Honey Show organized by the Warwickshire Beekeepers Association was a center of attraction with honey entries from all over the world. Other exhibits on view were a display of literary books and bee journals from different countries, the new four-language dictionary of Beekeeping terms, work done in the Bee Research Department of Rothamsted Experimental Station, and Mrs. Dorothy Hodges' pollen-load color chart and diagrams of pollen grains.

At the beginning of the Congress each member who registered was given a portfolio which contained all the papers presented. This could be obtained in French, German or English and is still available. One can order this through Hon. Secretary, Bee Research Assn., 520/1 Salisbury House, London Wall, London, E.C. 2. The price is 1 pound (about $2.80). There are also abstracts of all these papers in "The Bee World," Vol. 32, No. 11, Nov., 1951, and a report on the 1951 *Apimondia* meeting is given on page 83 and the draft Statutes proposed at that meeting occur on page 84 in the issue of "The Bee World" cited above.

Since the Congress did not run parallel sessions, many outstanding workers from various countries had no opportunity to present papers. This is one constructive criticism which might be considered before the next Congress, probably in a Scandinavian country in 1954.

HERMAN F. MENKE, JR.
State College of Washington, Pullman

NOTICE TO CONTRIBUTORS

The Business Manager has been somewhat embarrassed at times through a combination of circumstances in regard to the ordering of reprints. Without going into any of the details, the suggestions that are offered here will help you to get your reprints and help us in our relations with the printer.

1. Send your order to Ernest N. Cory, College Park, Maryland at the time you return your galley proof. If no blank is attached, request a blank from either this office or the printer.

2. Note on the blank whether an official order will follow.

3. If commercial concerns want additional reprints, note that an order from the firm will be sent.

4. Do not send orders directly to the printer or to the editor.

5. All orders must be sent from the Business Office to the printer *before* you receive your page proof (of the reprint).

NOTES

Dr. Ira M. Hawley retired from Federal service on October 12, 1951, after almost 26 years of service in the Bureau of Entomology and Plant Quarantine. Dr. Hawley was stationed at the Japanese Beetle Laboratory at Moorestown, N. J., at the time of his retirement. He is presently residing in Sepulveda, Calif.

Dr. Joseph L. King retired from Federal service on August 31, 1951, after almost 32 years of service in the Bureau of Entomology and Plant Quarantine. Dr. King was stationed at the Japanese Beetle Laboratory at Moorestown, N. J., at the time of his retirement, and is maintaining his residence at 503 Kings Highway, Moorestown, N. J.

Charles H. Hadley retired from Federal service on February 29, 1952, after almost 30 years of service in the Bureau of Entomology and Plant Quarantine. Mr. Hadley has been in charge of the Japanese beetle research work of the Bureau, with headquarters at Moorestown, N. J. He is maintaining his residence at 703 Redman Avenue, Haddonfield, N. J.

REPORTS OF THE BRANCHES AND SECTIONS

REPORT OF THE SECTION OF PLANT PEST CONTROL AND QUARANTINE

The following is a report of the meeting of the Section of Plant Pest Control and Quarantine of the AAEE, which was held in Cincinnati on December 11 at 1:30 P.M.

The meeting of the Section was concurrent with the joint meeting of the AAEE, the American Phytopathological Society, and the Entomological Society of America. Dr. Popham, Assistant Chief of the Bureau of Entomology and Plant Quarantine, was assigned as Chairman of this joint meeting. The program was given as listed on page 11 of the Program of the Cincinnati Meeting.

Following the presentation of the invitation papers of the Section there was a business session at which the undersigned was elected Chairman and Dr. H. M. Harris, State Entomologist, 311 Science Bldg., Iowa State College, Ames, Iowa, was elected Secretary.

The Secretary of the Section was unable to attend this meeting but the reports he has received from others in attendance indicated that the program of the joint session was an interesting one and well received by a large number of those in attendance at the meeting.

H. S. DEAN
Secretary, Plant Pest Control & Quarantine Section for 1951

REPORT OF THE SECTION OF TEACHING

The meetings of the Section on Teaching were held in the Pavilion Caprice of the Netherland Plaza Hotel, Cincinnati, Ohio, on December 12, 1951. This was a joint meeting with the members of the American Association of Economic Entomologists, the Entomological Society of America, and the American Phytopathological Society. The meeting was called to order at 1:30 P.M. by Chairman Lee H. Townshend of the University of Kentucky who appointed the following nominating committee: LAWRENCE A. HETRICK, *Chm.*, W. P. HAYES, and ALVAH PETERSON.

The program as presented was as follows:

1. The Forest Entomologist—Entomologist or Forester. S. A. GRAHAM, *University of Michigan.*
2. The Beginning Teacher: His Problems and Their Control. W. C. PADDOCK, *Pennsylvania State College.*
3. Evaluation of Student Achievement in Elementary Plant Pathology. W. H. BRAGONIER, *Iowa State College.*
4. Round Table Discussion—Joint Training in Plant Pathology and Entomology. Dr. G. C. KENT, *Moderator.*
   C. F. BISHOPP, *West Virginia University*
   J. H. LILLY, *Iowa State College*
   E. G. SHARVELLE, *Purdue University*
   M. C. SHURTLEFF, *University of Rhode Island*

After the round table discussion the following topics were presented by the person or persons whose name follows the topic. Following each report there was discussion of the topic by those in attendance.

5. Methods of teaching insect taxonomy and identification. LAWRENCE A. HETRICK, *University of Florida;* D. J. BORROR, *Ohio State University.*
6. Methods of teaching immature insects. ALVAH PETERSON, *Ohio State University.*
7. Methods of teaching insect physiology. FRANK W. FISK, *Ohio State University.*
8. What system is used by your department to see that your graduates get employment? What are your recent graduates doing? Has this affected your curriculum? WILLIAM E. BICKLEY, *University of Maryland;* HERMAN KING, *Michigan State College.*

After the last paper was presented, the Chairman called for the report of the Nominating Committee. They recommended the following nominees for the coming year: A. C. HODSON, *University of Minnesota,* CHAIRMAN; PAUL A. DAHM, *Kansas State College,* SECRETARY. Upon motion, duly seconded, these recommendations were approved.

Respectfully submitted,
RALPH H. DAVIDSON, *Secretary*

REPORT ON THE MEETING OF SECTION ON BIOLOGICAL CONTROL DECEMBER 10–13, 1951

A meeting of the Section on Biological Control was held on Monday evening, December 10, 7:30 to 10:30 P.M. The 12 papers presented were diversified and very informative. Some of the high spots were the parasites of Ensign wasps, predatory habits of species of *Polistes,* the artificial use of entomogenous fungi for the control of the alfalfa caterpillar, host plant resistance, and biological control of forest insects, the citrus blackfly in Mexico and *Planococcus citri* in greenhouses.

A short business meeting was held and officers were elected for the ensuing year. These were as follows:

CHAIRMAN	ALVAH PETERSON Ohio State University Columbus
SECRETARY	CURTIS P. CLAUSEN University of California Riverside

On Tuesday morning, December 11, 10:00 to 12:00 A.M., an informal round table discussion was held on biological control problems. Some twenty workers in this field attended this interesting session.

ALVAH PETERSON
Secretary
Section on Biological Control, A.A.E.E.

REPORT OF THE SECTION ON INSECTICIDES

Chairman: CARL J. WEINMAN

The Program Committee, with Carl J. Weinman, Illinois State Natural History Survey, as chairman, arranged two main topics with five invitation papers, which were presented on Thursday morning, December 13, 1951.

The first topic discussed by the leader, Dr. George C. Decker, Illinois State Natural History Survey was the fate of pesticidal residues on plants. Two papers were given on this subject as follows:

No. 1—Effects of physical properties and type of formulation on magnitude of deposit was presented by L. B. Norton, Cornell University. The factors of formulation, application technique, environmental conditions, surface tension and vapor pressure were named as important items in the study of the magnitude of deposit. The quantity of dust or spray that remains on a plant at the time of application depends largely upon the particle size, velocity of the particle and the nature of plant surface.

No. 2—Effects of weather on initial deposits and persistency of residues was presented by Jack E. Fahey, U. S. Department of Agriculture, Vincennes, Indiana. Since the weather plays an important part in residues several items such as temperature, wind and humidity are important. Heat increases volatization which may reduce droplet size due to increasing evaporation as well as reduce the residue deposited on the plants. The wind will effect the rate of evaporation as (a) increase rate of volatization, (b) bring deterimental gases in contact with residue, such as carbon dioxide etc., and (c) cause plant surfaces to rub against each other or blow off scales. Humidity has a very important part upon residues especially dust applications. Dew will cause dusts to adhere better and if excessive may even cause translocation.

The second topic discussed by Philip P. Wallace, Monsanto Chemical Co., St. Louis, Missouri, leader, was Evaluation of Test Methods. Three papers were given as follows:

No. 1—The evaluation of inhalation hazards associated with the use of pesticides was presented by E. M. Adams, Dow Chemical Company, Midland, Michigan.

The chemical industry today has the job of evaluating the health hazards of new products and of indicating precautions necessary for safe handling and use. A typical problem is presented by two liquid fumigants consisting of mixtures of carbon tetrachloride, ethylene dichloride, and ethylene dibromide. These are marketed under the names Dowfume EB-5 (R) (a grain fumigant) and Dowfume EB-15 (R) (A spot fumigant). Studies upon laboratory rats have shown that these mixtures produce essentially the same type of toxic injuries as do the separate constituents. These studies have also yielded certain quantitative measures of acute vapor toxicity.

Conclusions have been reached for human subjects based upon the data obtained with laboratory animals and upon the past experience of human subjects working with the separate constituents and with the "three and one" grain fumigant mixture (ethylene dichloride—three volumes, carbon tetrachloride—one volume). These conclusions have taken the form of intensities of vapor exposures without adverse effects in man. These intensities of exposures have served as a guide in evaluating the exposures of workmen in making and using the fumigants. Analytical studies during the use of these grain and spot fumigants, have demonstrated the magnitude of the vapor concentrations encountered by workmen and the circumstances or operations in which excessive exposures may occur. These findings permit the intelligent determination of operating procedures and precautions to assure the safety of workmen.

No. 2—Sampling and analysis of soils for insecticidal residues was presented by R. D. Chisholm, U. S. Department of Agriculture, Moorestown, N. J. There is no established test method for collecting or analyzing soil treated with insecticides. Samples of soil treated with insecticides are collected by taking a number of cores to form a composite and the test sample is collected from this. Stones are disregarded in soil samples if the analysis is determined upon pounds per acre.

Three inches of soil per acre weighs close to 1,000,000 lbs., however, this will vary with the type of soil. The analysis of residue in the soil is reported as weight to volume instead of weight to weight basis.

No. 3—The determination of the physiological effect on flavor from the application of insecticides was presented by Charles H. Mahoney, National Canners Association, Washington, D. C. The Residue Tolerance Hearings held by the Food and Drug Administration, showed a need for the use of pesticides for food production. The use of the new pesticides has developed the problem of off-taste and off-odor contamination in foods so the National Canners Association held a meeting on the West Coast in June 1951 for considering methods of product analysis. A steering committee was appointed at this meeting to consider all phases of test analysis of food products.

A testing program was established in California to evaluate pears, tomatoes and root crops. The possible residue on these crops is analyzed on unwashed, washed and processed foods. The processed foods will be tested at 3, 6, 12 and 18 month intervals. Plans are being made to establish similar testing programs in the Midwest, East and possibly Florida.

The presentation of new insecticides has become a regular feature of this section. The following new materials were announced:

(1) Geigy 338, an acaricide was announced by Geigy Co. Inc. Chemically it is 4,4-dichlorobenzilic-acid ethyl ester.

(2) Compound 269 was announced by Julius Hyman & Company. Chemically it is a stereoisomer of dieldrin.

(3) Compound 711 was announced by Julius Hyman & Company. Chemically it is a stereoisomer of aldrin.

At the business meeting the Secretary read a report from the Chairman of each Committee as follows:

(1) Biological Laboratory Methods of Insecticide Evaluation by Philip Wallace. This work was dropped in view of similar activites under the auspices of the National Research Council.

(2) Standardization of Test Insecticides by George S. Kido. A financial report regarding the handling, shipping, etc., of samples was made showing a surplus of $71.68 for the year. It was recommended that a semi-permanent committee be appointed by the Chairman of the Section on Insecticides so that the project may be perpetuated satisfactorily in the future.

(3) Sampling Technique for Evaluation of Pest Control Research by Lauren D. Anderson.

Several letters were sent to research workers for comments and suggestions. It seems advisable to divide the work into subcommittees to review all scientific research publications and a written summary be made of this study. All information obtained would be brought together and organized into one report and made available to interested persons.

The Nominating Committee made up of James Apple, Chairman, Ed H. Littooy and M. D. Farrar presented the following slate of Officers, which were elected by the Section:

Chairman—FRED FLETCHER, Dow Chemical Company, Midland, Mich.

Secretary—C. R. WEAVER, Agricultural Experiment Station, Wooster, Ohio

Respectfully submitted,
J. EVERETT BUSSART, *Secretary, Section on Insecticides*

REPORT OF THE MEETING OF THE SECTION OF APICULTURE

ANNUAL MEETING
AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

The Section of Apiculture met in Parlor L of the Netherland Plaza Hotel, Cincinnati, Ohio, Monday afternoon, December 10, 1951. Dr. W. A. Price, Lexington, Kentucky, Chairman, called the meeting to order at 1:40 P.M.

The Chairman requested a moment of silence in reverence to the late Dr. E. F. Phillips, Professor Emeritus of Apiculture, Cornell University, Ithaca, New York.

Appointment of Committees:

Nominations: H. A. Scullen and C. A. Reese
Resolutions: W. E. Dunham and M. H. Haydak

One invitation and seven submitted papers were presented as follows:

Invitation Paper

1. Breeding Improved Honeybees. W. C. Roberts, North Central States Bee Culture Laboratory, Madison, Wisconsin.

Submitted Papers

2. A Method of Measuring Pollination Populations on Field Crops. M. V. Smith and G. F. Townsend, Ontario Agricultural College, Guelph.
3. Cantaloup Production with Honeybees. S. E. McGregor and Frank E. Todd, Southwestern States Bee Culture Laboratory, Tucson, Arizona. Paper read by A. W. Woodrow.
4. Ecological Studies on Overwintering Honeybee Colonies. C. L. Farrar, North Central States Bee Culture Laboratory, Madison, Wisconsin. Paper read by W. C. Roberts.
5. Changes in the Thiamine Content of Adult Worker Honeybees on Protein-free Diet. M. H. Haydak, University of Minnesota, St. Paul.
6. Pollination of the Red Clover Flower by the Honeybee. A. W. Woodrow, Eastern U. S. Legume Seed Research Laboratory, Columbus, Ohio.
7. Influence of the Time of the Pollination Period on Red Clover Seed Yields. A. W. Woodrow.
8. Factors Influencing the "Set" of Recrystallized Honey. G. H. Austin and C. A. Jamieson, Department of Agriculture, Ottawa, Canada.

Papers read by title (authors not present) were as follows:

9. Toxicity of Certain Organic Insecticides to Honeybees. Nevin Weaver, Texas A. & M. College, College Station, Texas.
10. Summary of the XIV International Beekeeping Congress. H. F. Menke, State College of Washington, Pullman.

Business Meeting

The Resolutions Committee presented the following resolutions which were voted upon and passed by this Section.

1. Resolved: That the Secretary of this Section extend sincere sympathy to Mrs. E. F. Phillips and family because of the recent death of Dr. E. F. Phillips and furthermore this Section also wishes to express our admiration and recognition of the many scientific contributions in apiculture made by Dr. Phillips.
2. Resolved: That the Secretary of this Section convey appreciation to the Netherland Plaza Hotel management for the fine facilities and accommodations for this meeting.
3. Resolved: That the Local Committee of the American Association of Economic Entomologists be complimented for arranging for honey to be served at the banquet; moreover that this procedure be continued in succeeding years.
4. Resolved: That the members of this Section express their appreciation for the excellent work of the Chairman and Secretary the past year and during the present session of meeting.

The Nominations Committee presented the following nominees for the ensuing year, and they were unanimously elected.

Chairman: W. A. PRICE, Department of Botany and Entomology, University of Kentucky, Lexington

Secretary: R. L. PARKER, Department of Entomology, Kansas State College, Manhattan

The attendance was 30 persons from 16 states, Canada and Iran. The meeting adjourned at 4:50 P.M.

R. L. PARKER, *Secretary*

PROGRESS REPORT AAEE REFERENCE STANDARD PROGRAM COMMITTEE ON METHODS, SECTION ON INSECTICIDES AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

GEORGE S. KIDO
Nov. 30, 1951

The distribution of the AAEE Reference Standards was initiated on June 4, 1951 and to date 201 samples have been purchased by 50 individuals and organizations.

The financial status of the project may be presented as follows:

Order Position

Payments received		$198.10
Orders filled but unpaid		11.00
Total orders filled		$209.10
Expenses		
Labels	$101.75	
Packaging materials	27.87	
Shipping, postage, etc.	7.80	
Total expense		137.42
Surplus		$ 71.68

The labor and expense of preparing the samples for distribution was minimized by the fact that the insecticide industry donated the standards and in most instances furnished the standards in individual glass containers. The Committee on Methods expresses its gratitude for the fine cooperative effort on

the part of the following: American Cyanamid Company, California Spray Chemical Corporation, E. I. DuPont de Nemours & Company, Geigy Company, Hercules Powder Company, Monsanto Chemical Company and Velsicol Corporation.

Special credit is due to Dr. Bruce D. Gleissner, American Cyanamid Company for the preparation and design of the labels.

The time involved in the administration, packaging and shipping of the standards was donated by the Wisconsin Alumni Research Foundation.

Inasmuch as the Project Chairman's term expires at the end of 1951, it is recommended that a semi-permanent committee be appointed by the Chairman of the Section on Insecticides so that the project may be perpetuated satisfactorily in the future.

REPORT OF THE MEETING OF SECTION OF MEDICAL ENTOMOLOGY

The first session of the Section of Medical Entomology was called to order by the Chairman, E. F. Knipling, December 11 at 9:00 A.M. in the Hall of Mirrors of the Netherlands Plaza Hotel in Cincinnati. Due to the absence of the Secretary, D. E. Howell, A. D. Hess was appointed as Acting Secretary. The Chairman also appointed a nominating committee composed of R. W. Fay, Paul A. Dahm, and Colonel F. W. Whittemore, Chairman.

One invitational and twelve submitted papers were presented as follows:

Invitation Paper

1. Insect Problems of Medical Importance in Korea. Lt. Col. S. O. Hill, Entomologist, 8th Army, Korea.

Submitted Papers

1. Some Physiological Differences Between Strains of *Musca domestica* L. John Pratt, Jr. and Frank H. Babers, Bureau of Entomology and Plant Quarantine, Beltsville, Maryland.
2. The Principal Production Media of the Common Muscoid Flies. Thomas W. Haines, Communicable Disease Center, Public Health Service, Federal Security Agency, Thomasville, Georgia.
3. Fly Dispersion Studies in Metropolitan Areas. H. F. Schoof, R. E. Siverly, and J. A. Jensen, Communicable Disease Center, Public Health Service, Federal Security Agency, Atlanta and Savannah, Georgia.
4. Fly Dispersal in Rural Areas of Southeastern United States. K. D. Quarterman, John W. Kilpatrick, and Willis Mathis, Federal Security Agency, Public Health Service, Savannah, Georgia.
5. Fly Dispersal in Urban Areas of Southeastern United States. K. D. Quarterman, John W. Kilpatrick, and Willis Mathis, Federal Security Agency, Public Health Service, Savannah, Georgia.
6. A New Mechanical Device for Recording Knockdown of House Flies and Its Application in Evaluating Various Residual Deposits. Richard W. Fay, Robert L. Stenburg, and Ann Ernst, Federal Security Agency, Public Health Service, Savannah, Georgia.
7. Relative Efficiency of Several Methods of Applying Lindane in Enclosed Spaces. R. A. Fulton, R. P. Gelardo, and W. N. Sullivan, Entomology and Plant Quarantine, Beltsville, Maryland.
8. The Comparative Residual Toxicity upon Houseflies of Fog Applications of Certain Organic Insecticides. Dwight M. Delong, G. Mallory Boush, and Arden O. Lea, Department of Zoology and Entomology, Ohio State University, Columbus, Ohio.
9. Field Tests of Several Insecticides for the Control of Insecticide-Resistant House Flies. H. G. Wilson, R. S. Anders, and C. N. Husman, Bureau of Entomology and Plant Quarantine, Orlando, Florida.
10. Development of Resistance to Insecticides in Natural Populations of House Flies. I. H. Gilbert, M. D. Couch, and W. C. McDuffie, Bureau of Entomology and Plant Quarantine, Orlando, Florida.
11. Insect Control with Continuously Dispersed Lindane. Philip J. Spear, University of Massachusetts, Amherst.
12. Ectoparasitism of Norway Rats in an Inland New England Village Including a Comparison with that of a New England Seaport. Herbert Knutson and Raymond T. Szymkowicz, University of Rhode Island, Kingston.

The second session met in the Hall of Mirrors at 9:00 A.M. on Wednesday, December 12. The Chairman appointed the following to serve as a steering committee to assist the elected officers with the activities of the Section during the coming year: C. R. Twinn, W. C. McDuffie, and L. E. Chadwick, Chairman.

One invitational and twelve submitted papers were presented as follows:

Invitation Paper

1. The Significance of *Anopheles* Species Complexes in Problems of Disease Transmission and Control. Lloyd E. Rozeboom, John Hopkins University, Baltimore, Maryland.

Submitted Papers

1. Some Factors Affecting the Evaluation of Insecticides Against *Anopheles* Larvae. C. W. Kruse, G. F. Ludvik, and W. B. Hawkins, Tennessee Valley Authority, Wilson Dam, Alabama.
2. Mosquito Repellent Mixtures. Carroll N. Smith, M. M. Cole, G. W. Lloyd, and A. G. Selhime, Bureau of Entomology and Plant Quarantine, Orlando, Florida.
3. Further Studies on Dispersion of Flies Tagged With Radioactive Phosphorus. W. W. Yates And A. W. Lindquist, Bureau of Entomology and Plant Quarantine, Corvallis, Oregon.
4. Field Tests of Insecticides for the Control of Sand Flies. R. L. Goulding, J. Keller, G. C. LaBrecque, and R. F. Curran, Bureau of Entomology and Plant Quarantine, Orlando, Florida.
5. A Report on the Effectiveness of Certain Insecticides Against DDT Resistant Body Lice in Korea. G. W. Eddy, Bureau of Entomology and Plant Quarantine, Orlando, Florida.
6. Apparent Laboratory Transmission of Toxoplasmosis by Ticks and Lice. Paul. A. Woke, Leon Jacobs, and Frances E. Jones, Federal Security Agency, Public Health Service, Bethesda, Maryland.
7. Response of the German Cockroach to Sublethal Concentrations of DDT and Benzene Hexachloride. J. M. Grayson, Virginia Agricultural Experiment Station, Blacksburg.
8. DDT-Resistance Studies with the Oriental Rat Flea, *Xenopsylla cheopis* (Roth.). John W. Kilpatrick and Richard W. Fay, Federal Security Agency, Public Health Service, Savannah, Georgia.

9. Control of the Northern Feather mite of Poultry, *Fonsecaeonyssus* (*Liponyssus*) *sylviarum* (Can. et Fanzago). Dean P. Furman, University of California, Berkeley.
10. Cable-Type Black-Rubbers for Horn Fly Control. Wm. M. Roggoff and Alvin L. Moxon, South Dakota State College, Agricultural Experiment Station, Brookings.
11. Field Tests of Insecticides Against Ectoparasites of Poultry. Charles L. Smith, Bureau of Entomology and Plant Quarantine, Kerrville, Texas.
12. Studies of House Flies' Resistance to DDT in Canada. L. A. O. Roadhouse, Household & Medical Entomology Unit, Department of Agriculture, Ottawa.

The business meeting of the Section was held after the paper reading meeting on Wednesday morning. The nominating committee presented a slate of officers including two nominees for Chairman, and two for Secretary. There were no new nominations from the floor. In the election which followed A. W. A. BROWN was selected as *Chairman*, and CARROLL N. SMITH as Secretary for the coming year.

A. D. HESS, *Acting Chairman*

REPORT OF COMMITTEE ON INSECTICIDE TERMINOLOGY

The list of names and symbols presented below has been compiled by the Committee on Insecticide Terminology of the American Association of Economic Entomologists for use in the JOURNAL OF ECONOMIC ENTOMOLOGY. Some of these are approved common names, indicated by **, and others are interim designations that may be used until approved names have been established. Although some of the designations leave much to be desired, they have become so firmly established through continued use that a change does not seem in order. For the sake of uniformity and clarity it is requested that the same designations be used in all manuscripts and press releases issuing from the Bureau.[1]

It will not be necessary to include in manuscripts the definitions of the materials in this list.

NAME TO BE USED IN JOURNAL	DEFINITIONS	OTHER DESIGNATIONS THAT HAVE BEEN USED[1]
		(Not to be used in the JOURNAL)
aldrin**	not less than 95 per cent of 1,2,3,4,10,10-hexachloro-1,4,4a, 5,8,8a-hexahydro-1,4,5,8-dimethanonaphthalene	compound 118
allethrin**	*dl*-2-allyl-4-hydroxy-3-methyl-3-cyclopenten-1-one esterified with a mixture of cis and trans *dl*-chrysanthemum monocarboxylic acids	allyl homolog of cinerin I synthetic pyrethrins
Aramite*	product containing 2-(*p*-tertbutylphenoxy) isopropyl-1-methylethyl 2-chloroethyl sulfite	88R (alkyl aryl sulfite)
BHC	1,2,3,4,5,6-hexachlorocyclohexane, consisting of several isomers and containing 12 to 14 per cent of the gamma isomer	benzene hexachloride 666 gammexane*
chlordane**	1,2,4,5,6,7,8,8-octachloro-2,3,3a,4,7,7a-hexahydro-4,7-methanoindene	Velsicol 1068* Octachlor* Octa-Klor*
bis(*p*-chlorophenoxy) methane		K-1875 Neotran* di(4-chlorophenoxy)-methane
p-chlorophenyl *p*-chloro-benzene-sulfonate		K-6451 Ovotran*
compound 923	2,4-dichlorophenyl ester of benzene-sulfonic acid	Genitol 923
compound 22008	3-methyl-1-phenyl-5-pyrazolyl dimethylcarbamate	G-22008
CS-645A*	1,1-bis(*p*-chlorophenyl)-2-nitropropane	Prolan*
CS-674A*	1,1-bis(*p*-chlorophenyl)-2-nitrobutane	Bulan*
CS-708	mixture of 1 part 1,1-bis(*p*-chlorophenyl)-2-nitropropane (CS-645A) and 2 parts 1,1-bis(*p*-chlorophenyl)-2-nitrobutane (CS-674A)	Dilan*
D-D mixture	mixture of 1,2-dichloropropane and 1,3-dichloropropene	D-D*
DDT	commercially available dichlorodiphenyl-trichloroethane, the principal constituent of which is 1,1,1-trichloro-2,2-bis (*p*-chlorophenyl)ethane	chlorophenothane (U.S. Pharmacopoeia 14:136.1950)
DFDT	1,1,1-trichloro-2,2-bis(*p*-fluorophenyl)ethane	fluorine analog of DDT
dieldrin**	not less than 85 per cent of 1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-1,4,5,8-dimethanonaphthalene	compound 497
diisopropyl *p*-nitrophenyl thiophosphate	0,0-diisopropyl 0-*p*-nitrophenyl thiophosphate	compound 3456
dimethyl carbate	dimethyl ester of cis-bicyclo(2.2.1)-5-heptene-2,3-dicarboxylic acid	
DMC	4,4-dichloro-alpha-methyl benzhydrol	di(*p*-chlorophenyl) methylcarbinol 1,1-bis(*p*-chlorophenyl) ethanol Dimite*

NAME TO BE USED IN JOURNAL	DEFINITION	OTHER DESIGNATIONS THAT HAVE BEEN USED[1]
		(Not to be used in the JOURNAL)
E-1059	0-[2-(ethylmercapto)ethyl]0,0-diethyl thiophosphate	a trialkyl thiophosphate see Systox
EPN*	0-ethyl 0-*p*-nitrophenyl benzenethiophosphate	
ferbam**	ferric dimethyl dithiocarbamate	Fermate* Kerbam*
2-ethyl-1,3-hexanediol		Rutgers 612*
heptachlor**	1 (or 3a),4,5,6,7,8,8-heptachloro-3a,4,7,7a-tetrahydro-4,7-methanoindene	Velsicol 104* E-3314
HETP	mixture of ethyl polyphosphates containing 12 to 20 per cent of tetraethyl pyrophosphate	hexaethyl tetraphosphate
Indalone*	butyl ester of 3,4-dihydro-2,2-dimethyl-4-oxo-2H-pyran-6-carboxylic acid	n-butyl mesityl oxide oxalate Butopyronoxyl (U.S. Pharmacopoeia 14:91.1950)
lindane**	gamma isomer of benzene hexachloride of not less than 99 per cent purity	
malathon	0,0-dimethyl dithiophosphate of diethyl mercaptosuccinate	compound 4049 S-(1,2-dicarbethoxyethyl) 0,0-dimethyl dithiophosphate
Metacide*	product containing methyl parathion and parathion	
methoxychlor**	1,1,1-trichloro-2,2-bis(*p*-methoxyphenyl)ethane	Marlate* DMDT
methyl parathion	0,0-dimethyl 0-*p*-nitrophenyl thiophosphate	methyl homolog of parathion
4-methyl-umbelliferone 0,0-diethyl thiophosphate		0,0-diethyl thiophosphoric acid ester of 7-hydroxy-4-methylcoumarin Potasan* E-838
MGK-264*	N-(2-ethylhexyl)bicyclo(2.2.1)-5-heptene-2,3-dicarboximide	N-octylbicyclo (2.2.1)-5-heptene-2,3-dicarboximide Octacide 264* Van Dyk 264*
nabam**	disodium ethylene bisdithiocarbamate	Dithane*
para-oxon	diethyl *p*-nitrophenyl phosphate	oxygen analog of parathion E-600
parathion**	0,0-diethyl 0-*p*-nitrophenyl thiophosphate	E-605 compound 3422
piperonyl butoxide	product containing as its principal constituent alpha-[2-(2-butoxyethoxy)-ethoxy]-4,5-methylenedioxy-2-propyltoluene	(butyl carbitol) (6-propylpiperonyl) ether compound 312
piperonyl cyclonene	mixture of 3-alkyl-6-carbethoxy-5(3,4-methylenedioxyphenyl)-2-cyclohexen-1-one and 3-alkyl-5(3,4-methylenedioxyphenyl)-2-cyclohexen-1-one	di-*n*-propyl maleateisosafrole condensate
Q-137	1,1-dichloro-2,2-bis(*p*-ethylphenyl) ethane	
R-242	70 per cent of *p*-chlorophenyl phenyl sulfone plus 30 per cent of related sulfones	Sulphenone*
schradan	octamethyl pyrophosphoramide	bis(bis-dimethylamino)-phosphonous anhydride OMPA Pestox III*
Systox*	product containing E-1059	
sulfotepp	tetraethyl dithiopyrophosphate	dithione
TDE	commercially available dichlorodiphenyl-dichloroethane, the principal constituent of which is 1,1-dichloro-2,2-bis)*p*-chlorophenyl)ethane	DDD Rhothane*
TEPP	tetraethyl pyrophosphate	TEP
thiram**	tetramethylthiuram disulfide	
toxaphene**	chlorinated camphene having a chlorine content of 67–69 per cent	compound 3956
zineb**	zinc ethylene bisdithiocarbamate	
ziram**	zinc dimethyl dithiocarbamate	

* Trade name. Sometimes followed by a letter or a number, or both, which indicate a product of specific composition.

** Common names approved by Interdepartmental Committee on Pest Control.

[1] This list is not yet final. An amended list under consideration will supersede this when and if it is approved by the committee. (Ed.)

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NOTES

Grants for Scientific Research

The National Science Foundation, 2144 California Street, N.W., Washington 25, D. C., has issued a guide for the submission of research proposals. The Foundation has earmarked for the current year approximately $1,500,000 for the support of basic research in the mathematical, physical, medical, engineering and biological sciences. Grants may be made for such research to educational, industrial, governmental or other institutions or individuals. Their policy ordinarily is to award grants to institutions for research by specified individuals. Proposals are usually initiated by the interested scientist. He may submit a proposal at once or first discuss the project informally either by letter or in person with an appropriate member of the Foundation staff. When a grant is made, payments follows in advance on a quarterly, semi-annual, or annual basis depending on the size of the total grant.

There is no specific form for a proposal, but its handling is facilitated if it is submitted in 15 copies on letter size paper. The proposal should include the name and address of the institution, name of principal investigator, title and description of proposed research, procedure, facilities and major items of available equipment, a short biographical sketch and bibliography of the principal investigator and other professional personnel, and a budget comprising the total cost of the project, with a breakdown of costs for each year. The budget should be itemized and should cover salaries, permanent equipment, expendable equipment and supplies, travel, and other direct and indirect costs. Finally one copy of the proposal should be signed by the principal investigator, by the department head and by an official authorized to sign for the institution.

The Foundation expects to be advised of the progress of the work by quarterly or other financial reports and by annual progress reports. If information is developed that should be classified in the interest of national security, clearance may be required for investigators.

International Symposium on Desert Research Problems

The Research Council of Israel in cooperation with UNESCO is planning a symposium on Desert Research to be held at Jerusalem in May 1952. The purpose is to obtain an integrated picture of the present state of such research. The meetings will last about a week, four days being devoted to paper reading and the balance to excursions into the Negev, the arid zone in the south of Israel and visits to other places of interest. Five sections are planned for the symposium. These will be devoted to climate, soil, water, energy, biology. Specialists on these topics have been invited to participate. A preliminary and incomplete program includes on climate such speakers as Prof. J. B. Leighly of the University of California and Dr. W. S. Ladell, Physiological Research Unit, Oshodi, Nigeria. On soil, there will be Prof. W. C. Lowdermilk, and Dr. R. A. Bagnold, England. On water, there will be Mr. A. N. Khosla, Central Water and Power Commission, India, and Mr. P. Danel, Laboratoire Dauhinois d'Hydraulique, France. In the section on biology, various problems related to soil biology and to plants, animals and soil properties of desert areas will be discussed. In this section Prof. F. W. Went, California Institute of Technology will report on rain and temperature as effecting plant distribution in the desert, and Prof. Th. Monod, Institute Francais d'Afrique Noire, Dakar, French West Africa will contribute a paper.

Persons desiring to attend the symposium either in an official or private capacity should obtain application forms from S. Sambursky, Director, P.O. Box 607, Jerusalem, Israel or Mr. Victor A. Salkind, Scientific Adviser, 11 East 70th Street, New York 21, N. Y.

BOOK NOTICES

THE HOUSEFLY, ITS NATURAL HISTORY, MEDICAL IMPORTANCE, AND CONTROL, by Luther S. West. Comstock Publishing Company, Inc. Ithaca, New York, 1951. xvi+584 pp. 176 figures. Frontis. $7.50.

An exhaustive and comprehensive monograph about a single species, the common housefly. Living in a modern city or a small town where the garbage is collected twice weekly and burned, where sanitary measures prevail, where automobiles have replaced beasts of burden, and where houseflies are rarely seen, one is likely to get the idea that these insects are diminishing in importance.

An examination of Professor West's book will convince one that the housefly continues to be one of man's worst enemies, as a potential and active transmitter of bacterial, virus, and protozoan diseases. And various fly larvae are parasite, in their larval state, within the human body. In some parts of the world it is responsible for an enormous amount of human suffering. Professor West's volume includes the work of early investigators, the external and internal morphology of the housefly, its physiology, behavior, life history, taxonomy, distribution, food requirements, its parasites, predators, its relation to human disease, its use as an experimental animal, laboratory techniques, its control and the uses and dangers of the newer insecticides. Its 19 well written chapters are followed by a bibliography of approximately 1,100 titles, the whole constituting an outstanding and much needed, scholarly, source, of up-to-date information on all phases of the subject. It should be invaluable to public health officers, and to teachers and students of biology.

During the first half of the nineteenth century, "Baby-Bye" with its glorification of the housefly was a popular piece in the readers of that period. This however was before numerous pathogenic bacteria had been isolated from it. One may recall that the fly in these verses was a cute little animal, meant to amuse the baby, sometimes tickling baby's nose. Nowadays an informed mother would shudder if she saw this purveyor of filth, bacteria, protozoan cysts and helminth eggs, this wallower and feeder in fecal matter, this hairy vomiting distributor of 500,000,000 bacteria tickling her baby's nose.—H.B.W.

INSECT RESISTANCE IN CROP PLANTS, by Reginald H. Painter. The Macmillan Company, New York, 1951. 8¼×5½ inches. xii+520 pp. 67 figures. $8.50.

When most of us think of insect resistance in plants we remember the grape phylloxera, the hessian fly, and the woolly apple aphid but as a rule most of us are so permeated with the idea of insect control by chemicals that little thought is given to other means, especially that of the resistance of plants to insects. This is in spite of a large body of literature upon the subject partly in entomological magazines, but apparently mostly in journals devoted to botany, agronomy, horticulture, and in special publications that many entomologists seldom see. Then again, as insect resistance is a part of a plant breeding program, it requires an entomologist who understands genetics. And as Professor Painter has pointed out, research in such a field requires cooperation between the plant breeder, the agronomist or horticulturist and the entomologist, as well as the insect physiologist and the biochemist.

No one understands this field so well as Professor Painter who has studied insect resistance in crop plants at the Kansas Agricultural Experiment Station since 1926 and who deserves great credit for his comprehensive and intelligent summary of the literature of such research, tempered by his own knowledge and experience. In his stimulating book Professor Painter discusses the mechanisms of resistance, (including the various factors entering into its cause), the permanence of resistance (and the variables entering into plant-insect relationships), the resistance to insects in wheat, corn, cotton, sorghums and potato, and the methods and problems in plant breeding for resistance to insects. Each chapter is followed by an extensive bibliography.

In view of the extensive literature upon the subject, and the interest of so many workers, it is difficult to understand why research has not been prosecuted with greater vigor in all sections of the country. However it is an involved procedure and one in which the cooperation of other specialists is necessary. And in addition quick chemical controls appeal to many rather than more lasting, less costly methods.

In discussing resistance to hessian fly in wheat, Professor Painter states that there is a "complex genetic situation in the inheritance of fly-resistance and in factors affecting fly-resistance," and the thirty years after the first crosses were made, "fly-resistant wheats were being grown on several millions of acres." This goal was reached "without exact knowledge of the mechanism of resistance." In connection with the work done on the resistance to corn earworm in corn, it is brought out that the chief mechanisms are tightness of husks, hardness of the kernels, attractiveness for oviposition and value as food for larvae, with the last two being of major significance.

In his review of the literature of resistance to insects in crop plants, Professor Painter covers the important insect enemies of wheat, corn, cotton, sorghums and potato, and not only evaluates the work that has been done but points out where future work is necessary. Apparently basic data are needed in all such studies before hard and fast conclusions may be drawn.

Professor Painter has produced a well-written, stimulating volume describing a type of research work involving entomology, that has not received the coordinated, long-time attention it deserves.—H.B.W.

HORNED BEETLES, A STUDY OF THE FANTASTIC IN NATURE, by Gilbert J. Arrow, edited by W. D. Hincks. Dr. W. Junk, Publishers. The Hague, Netherlands. 1951. 8¼×6 inches. vi+154 pp. 15 plates containing 148 figures. Dutch Guild. 8.80.

This thoughtful and interesting essay by the late Gilbert J. Arrow, a lifetime student of the Coleoptera and a member of the staff of the British Museum for many years, is as its sub-title states, a study of the fantastic in nature. It discusses the horns and similar structures in beetles, the habits of horned beetles, the horns in male and female beetles, mandible horns and outgrowth horns in an attempt to arrive at an understanding of their significance. There seems to be a little evidence of horns being used as tools, the forelegs and mandibles being used in nidification. Their use in combats between rival

males is not very apparent. Both sexes of horned beetles may possess horns but as a rule only the male is horned, and the variety of his horns is endless. A study of the horns themselves exposes mostly their inconstancy. The vast majority defy any attempts to explain that they serve any purpose at all. A comparison is made with the horns of higher animals. Darwin's conclusion that horns are ornaments serving to attract the opposite sex, or sexual selection as applied to insects, is rejected, as it should be, in view of the fact that insect vision is relatively poor, and because the female exercises no choice and is the victim or companion of the male that first finds her. Although a few types of beetle-horns are explained on the basis of adaptations for certain activities such as ascending a vertical burrow, or in expelling excavated material, or the armature in other cases may be some protection from birds, their purpose, if any still remains a mystery. Mr. Arrow's book is highly readable and his discussions of the views of various authors, attack the subject from all angles. Mr. Arrow specialized in the study of these beetles and his opinions are worth reading, and of interest to both entomologists and biologists. The book is well illustrated and indexed.—H.B.W.

INSECT CONTROL BY CHEMICALS, by A. W. A. Brown. New York, John Wiley & Sons, Inc. London, Chapman & Hall, Limited. 1951. 8¼×5½ inches. viii+817 pp. $12.50.

No one interested in the control of insects by the use of chlorinated hydrocarbons, organic phosphates, various other synthetic organic compounds, insecticides of botanical origin, inorganic compounds, fumigants, oils, soaps. etc., can afford to be without this extensive summary of Dr. Brown, whose previous experience under the Directorate of Chemical Warfare ably fitted him to write this book.

Eleven chapters deal with the properties of present day insecticides, the relation between the molecular structure of organic chemicals and their toxicity to insects, mode of entry of insecticides, the pharmacology of insect poisons, spraying and dusting machinery, aircraft application of insecticides, hazards to man and domestic animals, toxicity of insecticides to plant growth, the chemical control of phytophagous insects, and of insects affecting man and animals and finally there is a discussion of the effects of the new insecticides on the balance of nature. Each chapter is extensively documented. In all approximately 2,300 references are cited in this exhaustive well-written and critical summary of the literature of insect control by chemicals. This brief notice does not do justice to the scope of this book and to the detailed information it contains on a multiplicity of related subjects.—H.B.W.

HANDBOOK OF AGRICULTURAL PEST CONTROL, by Stanley F. Bailey and Leslie M. Smith. Industry Publications, Inc., New York. 1951. 7½×5 inches. 191 pp. $3.25. Foreign and Canada, $3.75.

This is a highly useful handbook for those who no longer wish to apply fungicides and insecticides by rule of thumb, and who are anxious to operate within a narrow margin of error. In other words it is for intelligent farmers and pest control operators who are interested in keeping down costs and getting successful pest control at the same time. Section I is concerned with the agricultural chemicals, their physical and chemical properties, their compatibility, containers, fumigants and fumigation, toxicology and residues, and spray oil specifications. Section II deals with spraying machines, rates of application for sprays, delivery rates of machines, dusts and dusting and aircraft applications. Section III is devoted to mosquito control, the hazards of agricultural chemicals, repellents, defoliators, wood preservatives, tables, formulas, terms, symbols, conversion tables, etc.

The authors, both of the University of California, have packed into this book nearly everything one should know in order to apply agricultural chemicals intelligently. It is strictly for those who want to know what they are doing and it supplies a variety of information, not easily obtainable by most people.

In addition if there are any old time economic entomologists around who are still confused by the occupation of the youner men with machinery and chemistry instead of with insects, they would do well to study the Handbook by Bailey and Smith. They could then read the papers in the JOURNAL OF ECONOMIC ENTOMOLOGY with more understanding. —H.B.W.

AMERICAN SOCIAL INSECTS, by Charles D. Michener and Mary H. Michener. D. Van Nostrand Company, Inc. Toronto, New York, London. 1951. 8¼×5½ inches. xvi+267 pp. 109 figures including 30 in color. $6.00.

This is a book about bees, wasps, ants and termites written as an introduction to the behavior of of social insects by two entomologists who are saturated with knowledge of their subject. They have succeeded in producing an interesting and factual account of these social insects and although honeybees and ants have been written about extensively and popularly in the past, their accounts are fresh and stimulating. Only 14 pages are devoted to the honeybee and more attention is given to the lesser known stingless bees, bumblebees, and wild bees. Their survey of the ants includes the primitive ants, the army ants, the harvester ants, the fungus growers and the dairying ants. There are chapters on sensations and behavior, caste, how insects became social, subsocial insects, the parasites of social insects and on societies of insects and men. A brief appendix covers the elements of structure and classification and there is a helpful glossary and a bibliography. There are numerous excellent black and white illustrations and the colored illustrations are wonderful. Entomology could easily stand more introductions of this kind, and the social insects with their fascinating behavior was a happy choice. And the authors too were a happy choice.

This book is one of the New Illustrated Naturalist series which are noted for their authenticity for their readability and for the excellence of their illustrations. It is good to have these accounts of the social insects between two covers.—H.B.W.